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# INTERNATIONAL RICE RESEARCH NEWSLETTER

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# IRRN GUIDELINES

The *International Rice Research Newsletter* objective is:

"To expedite communication among scientists concerned with the development of improved technology for rice and for rice-based cropping systems. This publication will report what scientists are doing to increase the production of rice, inasmuch as this crop feeds the most densely populated and land-scarce nations in the world . . IRRN is a mechanism to help rice scientists keep each other informed of current research findings."

The concise reports contained in IRRN are meant to encourage rice scientists and workers to communicate with one another. In this way, readers can obtain more detailed information on the research reported.

Please examine the criteria, guidelines, and research categories that follow.

If you have comments or suggestions. please write the editor, IRRN, IRRI, P.O. Box 933, Manila, Philippines. We look forward to your continuing interest in IRRN.

## Criteria for IRRN research reports

- has international, or pan-national, relevance
- has rice environment relevance
- advances rice knowledge
- uses appropriate research design and data collection methodology
- reports appropriate, adequate data
- applies appropriate analysis, using appropriate statistical techniques
- reaches supportable conclusions

## Guidelines for contributors

The *International Rice Research Newsletter* is a compilation of research briefs on topics of interest to rice scientists all over the world. Contributions to IRRN should be reports of recent work and work-in-progress that have broad interest and application. Please observe these guidelines in preparing submissions:

- The report should not exceed two pages of double-spaced typewritten text. No more than two figures (graphs, tables, or photos) may accompany the text. Do not cite references or include a bibliography. Items that exceed the specified length will be returned.
- Include a brief statement of research objectives and project design. The discussion should be brief, and should relate the results of the work to its objectives.
- Report appropriate statistical analysis.
- Provide genetic background for new varieties or breeding lines.
- Specify the environment (irrigated, rainfed lowland, upland, deep water, tidal wetlands). If you must use local terms to specify landforms or cropping systems, explain or define them in parentheses.
- Specify the type of rice culture (e.g. transplanted, wet seeded, dry seeded).
- Specify seasons by characteristic weather (wet, dry, monsoon) and by months. Do not use national or local terms for seasons or, if used, define them.
- When describing the rice plant and its cultivation, use standard, internationally recognized designators for plant parts and growth stages environments, management practices, etc. Do not use local terms.
- When reporting soil nutrient studies, be sure to include standard soil profile description, classification, and relevant soil properties.
- Provide scientific names for diseases, insects, weeds, and crop plants; do not use common names or local names alone.
- Survey data should be quantified (infection percentage, degree of severity, sampling base, etc.).
- When evaluating susceptibility, resistance, tolerance, etc., report the actual quantification of damage due to stress used to assess level or incidence. Specify the measurements used.
- Use international measurements. Do not use local units of measure. Express yield data in metric tons per hectare (t/ha) for field studies and in grams per pot (g/pot) or per row (g/row) for small-scale studies.
- Express all economic data in terms of the US$. Do not use national monetary units. Economic information should be presented at the exchange rate $:local currency at the time data were collected.
- Use generic names, not trade names, for all chemicals.
- When using acronyms or abbreviations, write the name in full on first mention, following it with the acronym or abbreviation in parentheses. Thereafter, use the abbreviation.
- Define in a footnote or legend any nonstandard abbreviations or symbols used in a table or figure.

## Categories of research reported

GERMPLASM IMPROVEMENT
- genetic resources
- genetics
- breeding methods
- yield potential
- grain quality and nutritional value
- disease resistance
- insect resistance
- drought tolerance
- excess water tolerance
- adverse temperature tolerance
- adverse soils tolerance
- integrated germplasm improvement
- seed technology
- research techniques
- data management and computer modeling

CROP AND RESOURCE MANAGEMENT
- soils and soil characterization
- soil microbiology and biological N fertilizer
- physiology and plant nutrition
- crop management
- soil fertility and fertilizer management
- disease management
- insect management
- weed management
- managing other pests
- integrated pest management
- water management
- farm machinery
- environmental analysis
- postharvest technology
- farming systems
- research methodology
- data management and computer modeling

SOCIOECONOMIC AND ENVIRONMENTAL IMPACT
- environment
- production
- livelihood

EDUCATION AND COMMUNICATION
- training and technology transfer research
- communication research
- Information storage and retrieval

# CONTENTS

# GERMPLASM IMPROVEMENT

## Breeding methods

### Agronomic performance and genetic correlations of rice mutants

*M. L. H. Kaul and Neelangini, Botany Department, Kurukshetra University, Kurukshetra 132119, India*

By using different mutagen doses, we isolated five mutants in rice varieties IR8, Jhona, and Basmati (Table 1). Both mutants of IR8 ($IRm_1$ and $IRm_6$) are early and fine-grained, with higher seed protein content. Both mutants of Jhona ($Jm_1$ and $Jm_4$) are shorter and yield higher than their parent. $Jm_4$ has higher grain number and grain yield than $Jm_1$. Basmati mutant $Bm_1$ has shorter duration and is shorter and has finer grains, with higher grain number, protein content, and seed yield, than Basmati.

Although the genetic parameters phenotypic and genotypic coefficients of variation, heritability, genetic advance, and expected genetic advance were not different in the mutants, significant differences in certain genetic correlations were exhibited (Table 2). Grain yield became negatively correlated with grain fineness and positively correlated with grain weight; these correlations are not significant in the parent varieties. Grain fineness in the parent varieties is not correlated with grain weight and grain number; in the mutants, these correlations are negative and significant. Shoot height in the mutants is negatively correlated with grain weight; in the parents, this correlation is not significant.

Whether these represent mutational changes or chance changes needs to be determined, using a large sample of mutant types. ☐

**Table 1. Performance of rice mutants and their parent lines. Kurukshetra University, India.**

| Parent and mutant | Mutagen and dosage[a] | Shoot height[a] (cm) | Maturity[a] (d) | Fertile grain[a] (no.) | Grain fineness[a] | Grain yield[a] (g/plant) | Seed protein content[b] (%) |
|---|---|---|---|---|---|---|---|
| IR8 | – | 88.1 | 153 | 753 | 2.39 | 21.1 | 7.6 |
| $IRm_1$ | EMS 1.5% | 110.5 | 128 | 903 | 2.84 | 22.7 | 8.2 |
| $IRm_6$ | EMS 1.5% | 88.7 | 119 | 982 | 2.66 | 22.5 | 8.7 |
| LSD (0.05) | | 3.9 | 5.7 | 19.9 | 0.13 | 1.2 | 0.2 |
| Jhona | – | 133.5 | 127 | 1012 | 2.29 | 20.4 | 7.8 |
| $Jm_1$ | EMS 1.5% | 122.9 | 125 | 1081 | 2.45 | 22.9 | 7.9 |
| $Jm_4$ | r-rays 20 kR + 1% EMS | 124.5 | 123 | 1130 | 2.47 | 24.1 | 7.7 |
| LSD (0.05) | | 5.8 | 7.4 | 28.31 | 0.09 | 1.6 | 0.15 |
| Basmati | – | 151.8 | 152 | 789 | 3.63 | 15.9 | 7.6 |
| $Bm_1$ | EMS 0.5% | 140.7 | 142 | 878 | 3.60 | 17.4 | 8.4 |
| LSD (0.05) | | 5.2 | 4.5 | 21.6 | 0.08 | 0.1 | 0.1 |

[a]Mean of 360 observations (40 plants × 3 replications × 3 generations). [b]Mean of 90 observations (10 plants × 3 replications × 3 generations).

**Table 2. Correlations[a] of genetic traits between parent varieties and mutant lines. Kurukshetra University, India.**

| Trait | | GY | GF | GW | GN | SH |
|---|---|---|---|---|---|---|
| Grain yield (GY) | Parent | ns | ns | ns | + | ns |
| | Mutant | ns | – | + | + | ns |
| Grain fineness (GF) | Parent | .05 | ns | ns | ns | + |
| | Mutant | –.29* | ns | – | – | + |
| Grain weight (GW) | Parent | .15 | –.49 | ns | – | ns |
| | Mutant | .29* | –.25* | ns | – | – |
| Grain number (GN) | Parent | .70* | .39 | –.59* | ns | ns |
| | Mutant | .22* | –.14* | –.23* | ns | ns |
| Shoot height (SH) | Parent | –.02 | .39* | –.15 | .09 | ns |
| | Mutant | .23 | .31* | –.28* | .21 | ns |

[a]ns = not significant, + = positive, – = negative, * = significant value, SE > n̄.

### Hybrid rice heterosis in Tamil Nadu

*M. Rangaswamy and K. Natarajamoorthy, School of Genetics, Tamil Nadu Agricultural University, Coimbatore 641003, India*

We studied 38 $F_1$s involving Zhen Shan 97A and Er-jiu-Nan 1A as the female parents during 1985 dry season. All combinations had high standard heterosis and heterobeltiosis for tiller numbers (see table).

High tiller numbers were reflected in straw yield, with standard heterosis as high as 134% and heterobeltiosis as high as 112%. Standard heterosis for grain yield was only 8%, because of heterosis for spikelet sterility as high as 226% compared to the standard variety and 909% compared to the pollen parents.

Heterosis for tiller number gives scope for improving hybrid seed fertility by selecting restorers for genetic constitution and CMS lines for cytoplasmic content. ☐

**Heterosis [a] in 38 combinations. Coimbatore, India, 1985 dry season.**

| Character studied[b] | 26 combinations (ovule parent used: Zhen Shan 97A) | | | | 12 combinations (ovule parent used: Er-jiu-Nan 1A) | | | |
|---|---|---|---|---|---|---|---|---|
| | Range of standard heterosis (%) | | Range of heterobeltiosis (%) | | Range of standard heterosis (%) | | Range of heterobeltiosis (%) | |
| | From | To | From | To | From | To | From | To |
| Plant ht (cm) | –42.53 (Kanchi) | –2.12 (K. Samba) | –49.72 (PTB10) | +17.81 (TNAU658) | –34.09 (IET5103) | 11.12 (IR9698) | –41.32 (IET6208) | +7.12 (IR19053) |
| Tiller number per plant | +100.00 (IET1722) | +242.85 (TNAU4372) | +111.11 (Co 13) | +242.85 (TNAU4372) | +117.14 (IET3267) | +222.85 (IR2307) | +111.11 (IET3267) | +207.93 (IR9715) |
| Panicle length (cm) | –19.46 (Co 33) | +0.44 (ASD8) | –24.80 (BAS370) | +25.41 (ASD8) | –19.02 (IR9698) | –2.21 (IR19053) | –18.30 (IR9698) | +11.61 (IR19053) |
| Spikelets per panicle | –65.85 (TNAU658) | –9.15 (Co 37) | –54.10 (TNAU658) | +41.84 (IR50) | –48.17 (IR9698) | –12.80 (AS19789) | –67.81 (IET6208) | +53.32 (IR2307) |
| Grain yield per plant (g) | –81.77 (BAS370) | –8.33 (AD9246) | –87.27 (BAS370) | –3.82 (AD9246) | –65.26 (IR19053) | +7.89 (IET6208) | –69.01 (IET5103) | +11.11 (IR9698) |
| Grain number per panicle | –93.6 (ADT31) | –74.4 (K. Samba) | –93.10 (ADT31) | –43.01 (IR36) | –94.16 (IR2307) | –47.76 (IET6208) | –87.14 (IR2307) | –36.19 (IR19053) |
| Unfilled grains per panicle | –5.12 (TNAU658) | +238.46 (Co 37) | +77.94 (TNAU4372) | +728.57 (PY2) | –46.93 (IET5103) | +226.02 (IET3630) | +7.21 (IET5103) | +908.94 (IR2307) |
| Straw wt (g) | –42.50 (IR9752) | +91.25 (IR56) | –47.50 (TNAU4372) | +90.62 (Co 37) | –30.00 (IR19053) | +134.37 (IET6208) | –11.66 (IR18599) | +111.65 (BPHR5) |

[a]Standard heterosis compared with Co 37, heterobeltiosis compared with pollen parent. Variety in brackets = pollen parent. [b]Av for 5 plants.

## Variation in stigma exsertion in rice

*Xu Yun-bi. Zhejiang Agricultural University, Hangzhou; Shen Zong-tan, Zhejiang Agricultural University and China National Rice Research Institute (CNRRI), Hangzhou; and Ying Cun-shan and Yang Zai-neng, CNRRI, Hangzhou, China*

Stigma exsertion rate (SER) in 105 cultivars from Zhejiang and Taiwan, China, and from India was examined in late 1983 and 21 floral and panicle characteristics including stigma exsertion were examined in 330 cultivars from Taihu Valley and Yunnan Province in late 1984. Variation in SER in relation to other agronomic and morphological traits was examined by correlation, path, cluster, and principal component analyses.

SER ranged from 0 to 76% (mean 12.8%) among the cultivars observed in 1983 (see table). SER was 0-76% (mean 19.9%,) in indica rices and 0-40% (mean 5.9%) in japonicas. SER ranged from 0 to 69% (mean 8.5%) among the cultivars observed in 1984. The mean SER in indicas (19.3%) was higher than that in japonicas from Taihu Valley (3.2%), but lower than that in japonicas from Yunnan plateau (25.2%). Upland rices showed higher SER (18.8% in 1983 and 30.5% in 1984) than lowland rices (11.2% in 1983 and 5.3% in 1984).

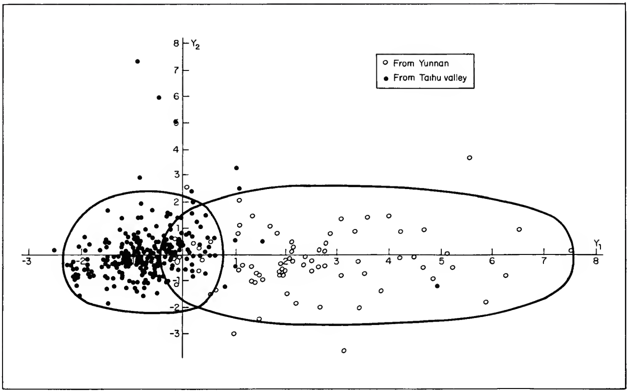
**Variation in SER in cultivars. Hangzhou, China, 1983-84.**

| Cultivars: Type | Cultivars: No. | SER (%): Mean | Upland rice: Mean | Upland rice: Range | Lowland rice: Mean | Lowland rice: Range |
|---|---|---|---|---|---|---|
| Observed in 1983 | 105 | 12.8 | 18.8 | 0 -54.3 | 11.2 | 0-75.9 |
| Indicas | 52 | 19.9 | 21.1 | 2.3-34.8 | 19.4 | 0-75.9 |
| Japonicas | 53 | 5.9 | 14.7 | 0 -54.3 | 2.3 | 0-39.7 |
| Observed in 1984[a] | 330 | 8.5 | 30.5 | 5.6-54.2 | 5.3 | 0-68.6 |
| Indicas | 19 | 19.3 | 30.7 | 10.5-52.6 | 16.3 | 0-63.2 |
| Japonicas | 306 | 7.6 | 30.5 | 5.6-54.2 | 5.6 | 0-68.6 |
| From Yunnan | 84 | 23.2 | 30.5 | 5.6-54.2 | 20.7 | 0-68.6 |
| Indicas | 18 | 16.9 | 30.7 | 10.5-52.6 | 12.9 | 0-46.3 |
| Japonicas | 61 | 25.2 | 30.5 | 5.6-54.2 | 22.9 | 0-68.6 |

[a]Some cultivars from Yunnan were medium type in indica-japonica differentiation.

Cultivars from Yunnan could be divided into two groups on the basis of differences in SER, which were in proportion to numbers of lowland and upland rices. Differences between cultivars from Yunnan and Taihu Valley on the scatter diagram were in concordance with differences in SER (see figure).

Major characteristics contributing to SER were classified as stigma characteristics (outwardly curved stigma, pistil length, number of stigma branches), spikelet characteristics (length, width, and length:width ratio), and angle of floret opening. Glume pubescence and awn length also may be used as indirect indices of SER. ☐




Two-dimension ordinations of 330 cultivars observed in Hangzhou, China, 1983.

## Possibility of transferring apomixis from sorghum to rice

*U. R. Murty and E. C. Cocking, Plant Genetic Manipulation Group, University of Nottingham, United Kingdom*

Apomixis can be exploited for the fixation of heterosis in hybrid rice. However, no cultivated or wild rice species with apomictic modes of reproduction are known. The only cereal in which a high frequency of facultative apomixis (80%) has been exploited is grain sorghum. We attempted intergeneric transfer of apomixis using protoplast fusion.

An embryogenic cell suspension culture LB-1 of rice variety T309 is available as a source of protoplasts at Nottingham University. Sorghum protoplasts can be isolated from leaves. Using standard procedures, protoplasts from the LB-1 suspension culture of T309 and mesophyll protoplasts from the apomictic sorghum line R473 were isolated. Rice protoplasts were vitally stained with fluorescein diacetate (FDA) to facilitate identification.

After washing in electrofusion solution, protoplasts were mixed in a ratio of 1:1. Fusion was accomplished using Watts and King electrofusion equipment. Alignment of protoplasts was obtained in an AC field of 500 KHz volts for 20 s. A high frequency (6-8%) protoplast fusion was obtained with a 400 V DC pulse for 2 µs. The mixture of unfused protoplasts and heterokaryons was plated in sea plaque agarose in petri plates, with the position of heterokaryons marked with ink dots.

Within 10-12 d, the heterokaryons had formed walls and undergone 3 divisions. There was no subsequent development.

Further manipulation of the cultural conditions (prior conditioning of the medium with T309 callus, change in the composition of the medium, nurse culture, etc.) could help realize regenerated somatic hybrids. In similar intergeneric somatic hybrids, the genome of one parent is eliminated. It should be easy to screen progeny of regenerated rice plants for apomixis. □

## Receptivity of exserted stigmas

*Xu Yun-bi, Zhejiang Agricultural University; and Shen Zong-tan, China National Rice Research Institute, Hangzhou, China*

Experimental evidence suggests that exserted stigma traits, in particular its receptivity (probability of fertilization and seed set on spikelets with exserted stigma by artificial pollination after flowering) in CMS lines would increase outcrossing rates. We analyzed cultivars Xie-qing-zao (completely male sterile) and selections 25154 and 97154 (both partially male sterile) with exserted stigma, and Er-jiu-qing with non-exserted stigma for stigma receptivity to alien pollen at Linshui, Hainan, China, in spring 1984.

Exserted stigma showed higher receptivity within 1-2 d after flowering (see table). Seed set after pollination was in direct proportion to percentage exserted stigma (PES), and seed set was higher on spikelets with double exserted stigma than on those with single exserted stigma. With pollination the second day after flowering, seed set on spikelets with double and single exserted stigma was 0 in Xieqing-zao A, 20% in 25 154, and 51% in 97 154, indicating marked differences in stigma receptivity.

Receptivity was also closely associated with stigmatic characteristics. Stigma breadth was 0.36 mm in 25154 and 0.37 mm in 97154, but only 0.30 mm in Xieqing-zao. Xieqing-zao stigmas were slender and less branchy, easily damaged when protruded, and dried quickly after flowering, losing receptivity.

Percentage seed set on spikelets with exserted stigma 2 d after flowering may be used as an index of receptivity of exserted stigma. Stigma exsertion makes it possible to breed CMS lines with higher PES and to improve the outcrossing rate. □

**Exserted stigma and seed set under artificial pollination by day after flowering.[a] Linshui, Hainan, China, 1984 spring.**

| Cultivar | Pollination day after flowering[b] | Spikelets (no.) | Exserted stigma (%) | Seed set (%) in spikelets | | | |
|---|---|---|---|---|---|---|---|
| | | | | Total (exserted and nonexserted) | Exserted stigma | Double exserted stigma | Single exserted stigma |
| 97154 sel. | Check | 315 | 59.4 | 2.9 | 4.8 | 7.7 | 3.3 |
| | Same day | 241 | 63.9 | 45.6 | 71.4 | 70.5 | 71.8 |
| | Day 1 | 217 | 68.2 | 32.3 | 47.3 | 80.0 | 35.2 |
| | Day 2 | 240 | 62.9 | 32.1 | 51.0 | 72.5 | 43.2 |
| 25154 sel. (artificially emasculated) | Check | 230 | 32.6 | 0 | 0 | 0 | 0 |
| | Day 1 | 125 | 53.6 | 23.2 | 43.3 | 73.3 | 34.6 |
| | Day 2 | 121 | 46.3 | 9.1 | 19.6 | 33.3 | 17.0 |
| Xieqing-zao | Check | 105 | 18.1 | 0 | 0 | 0 | 0 |
| | Day 1 | 129 | 29.5 | 8.5 | 29.0 | 71.4 | 19.4 |
| | Day 2 | 93 | 23.7 | 0 | 0 | 0 | 0 |
| | Day 3 | 83 | 21.7 | 0 | 0 | 0 | 0 |

[a]Er-jiu-qing had no seed set after pollination on the same day, day 1, and day 2. [b]Check = no pollination.

# Yield potential

## Rice heterosis for panicle branching, spikelet number, and vascular bundle number

*S. Mallik, R. Robles, A. Aguilar, and B. S. Vergara, Plant Physiology Department, IRRI*

Heterosis for 9 quantitative characters was assessed in crosses using 7 high density (HD)-grain parents (at least 30% of the grains having specific gravity greater than 1.20) and 2 low density (LD)-grain parents.

Estimates of overall degree and direction of heterosis were positive and significant for number of secondary branches, number of spikelets on secondary branches, and number of inner vascular bundle, indicating dominance of higher values (Table 1). Heterosis was negative for number of spikelets on tertiary branches and number of outer vascular bundles where genes of lower count dominated. Low or nonsignificant heterosis for other characters may be due to little genetic interactions or differences among parents.

Values for individual $F_1$ families differed from overall estimates for different characters, showing positive, negative, or no heterosis (Table 2). The $F_1$ means deviated conspicuously from parental and midparental values, indicating involvement of nonadditive gene action in the expression of most characters.

Substantial heterosis in the desirable direction was observed in number of primary branches, number of spikelets on primary branches, inner vascular bundles, and outer vascular bundles. Three crosses among HD-grain parents and one cross between HD- and LD-grain parents exhibited positive heterosis for number of primary branches. The cross P2/ P9 manifested positive heterosis for all other characters. Positive heterosis for total number of spikelets was observed in all crosses except P3/P8, through spikelet numbers on primary, secondary, and tertiary branches. Number of inner vascular bundles exhibited positive heterosis in most crosses, but the reverse was true for number of outer vascular bundles.

**Table 1. Overall parental and $F_1$ means and deviation for 9 quantitative yield characters. IRRI, 1988.**

| Character | Mean of parents (P) | Mean of $F_1$s ($F_1$) | Overall heterosis ($F_1$-P) | LSD (0.05) |
|---|---|---|---|---|
| Primary branches (no.) | 11.31 | 11.27 | –0.04 | 0.25 |
| Secondary branches (no.) | 33.09 | 34.96 | 1.87 | 1.56 |
| Tertiary branches (no.) | 0.91 | 0.64 | –0.27 | 0.29 |
| Spikelets on primary branches (no.) | 66.64 | 65.53 | –1.11 | 2.79 |
| Spikelets on secondary branches (no.) | 113.40 | 120.74 | 7.34 | 7.29 |
| Spikelets on tertiary branches (no.) | 2.40 | 1.44 | –0.96 | 0.86 |
| Total spikelets (no.) | 182.30 | 187.74 | 5.44 | 8.21 |
| Inner vascular bundles (no.) | 23.12 | 23.98 | 0.86 | 0.52 |
| Outer vascular bundles (no.) | 23.43 | 21.94 | –1.49 | 0.86 |

As panicles with more primary branches accommodate more HD grains, substantial heterosis for that character may lead to higher yield. The three crosses with IR30 (P2) as a common parent in either direction (P5/ P2, P1 / P2, and P2/ P9) had positive heterosis for panicles with more primary branches. □

**Table 2. Heterosis percentage of 9 quantitative yield characters. IRRI, 1988.**

| Character | Heterosis (%) in given cross[a] | | | | | | | LSD (0.05) |
|---|---|---|---|---|---|---|---|---|
| | P1/P2 (HD/HD) | P3/P4 (HD/HD) | P5/P2 (HD/HD) | P2/P6 (HD/HD) | P4/P7 (HD/HD) | P3/P8 (HD/LD) | P2/P9 (HD/LD) | |
| Primary branches | 5.21 | 1.69 | 9.42 | –1.38 | –7.23 | –9.31 | 3.35 | 1.82 |
| Secondary branches | 0 | 9.77 | 4.75 | 6.00 | 23.63 | –5.93 | 35.34 | 6.75 |
| Tertiary branches | –39.39 | –80.95 | –100.00 | 11.11 | 80.00 | 12.00 | 150.00 | 27.00 |
| Spikelets on primary branches | 13.64 | 1.31 | 15.36 | –7.49 | –18.48 | –2.38 | 4.25 | 3.66 |
| Spikelets on secondary branches | 0.67 | 11.78 | 4.89 | 15.63 | 32.85 | –2.33 | 28.69 | 6.83 |
| Spikelets on tertiary branches | –56.96 | –88.73 | –100.00 | 33.33 | 62.50 | –18.99 | 122.00 | 19.70 |
| Total spikelets | 3.50 | 5.90 | 7.92 | 6.09 | 11.82 | –2.67 | 19.51 | 3.12 |
| Inner vascular bundles | 4.86 | 2.15 | 1.07 | 1.73 | –1.39 | –0.44 | 9.33 | 1.68 |
| Outer vascular bundles | 1.79 | –4.81 | –11.34 | –1.37 | –11.24 | –1.38 | 3.27 | 2.38 |

[a]P1 = 1R32307-75-1-3-1, P2 = IR30, P3 = IR34615-75-1-1, P4 = IR29725-135-2-2-3, P5 = 1R29692-117-1-2-2, P6 = IR35337-61-2-2-2, P7 = 1R28211-43-1-1-1-2, P8 = IR32419-102-3-2-3, P9 = 1R32385-37-3-3-3.

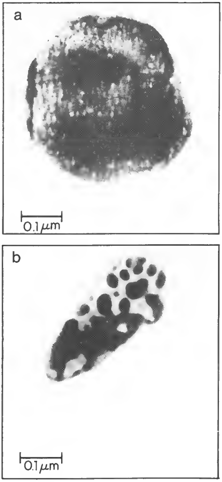
## Influence of silicon and its antagonists on rice mitochondria

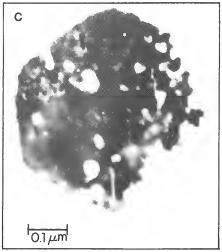
*N. E. Alyoshin, E. R. Avakyan, E. V. Lebedev, and E. P. Alyoshin, All-Union Rice Research Institute, P.O. Belozernoe, Krasnodar 353204, USSR*

Silicon is beneficial to rice plant growth and development, but the mechanisms of its biological activity are obscure.

Si physiological antagonists As and Ge suppress rice plant growth and dry matter accumulation and induce necrosis. We studied rice mitochondria morphology to test the assumption that Si can stabilize and As and Ge can damage the energy-producing systems of the rice cells.

Rice variety Krasnodarsky 424 seedlings were grown to the 2-leaf stage in water culture, with 60 µmol Si in treatment 1, 60 µmol Ge in treatment 2, and 60 µmol As in treatment 3. Mitochondria were isolated with the sediments in 0.05 M tris-HC1; 0.01 M EDTA; 0.05% cystein (pH 7.4) buffer. The isolated mitochondria were fixed with gluteraldebyde and osmiate, contrasted with uranylacetate, stained




Mitochondrion in treatment with 60 µmol Si (a) and 60 µmol Ge (b), and destruction of spherical mitochondrion (c).

with Pb-citrate, and studied under an electron microscope.

Mitochondria in the Si treatment were almost uniform, spherical particles 0.2-0.5 µm in diameter (see figure). Mitochondria in the Ge suspension were about 50% smaller and elongated. Material of different electron densities distributed sporadically on the surface can be explained as either injury of

the surface membrane or as Ge accumulation in the surface membrane.

The As suspension showed about 40% destruction of the spherical mitochondrion. That can be explained by the As mechanism of arsenolysis of macroergical compounds, leading to mitochondria membrane degradation. □



# Grain quality and nutritional value

## Grain quality of new Pakistani rice lines

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Four promising lines—AS688, IR25588-7-3-1, IR28128-45-2, and PND160-2-1—from the 1985 Irrigated Rice Yield Nursery-Very Early yielded higher than local varieties grown in Mansehra and Muzaffarabad. The lines were further tested 1986-87 in microplot trials.

On the basis of total milling recovery, physical dimensions, chemical properties, and cooking and eating quality, AS688 resembled JP5, IR28128-45-2 resembled DR83, and PND160-2-1 resembled KS282 (see table).

The new lines are likely to be acceptable to local millers and consumers. □

**Grain characteristics of 4 early-maturing rice lines and 3 local commercial varieties.[a] Pakistan, 1985-87.**

| Entry | Total recovery (%) | Head rice (%) | Grain length (mm) | Grain breadth (mm) | Length-to-breadth ratio | Size/ shape[b] | Grain thickness (mm) | Quality index $\left(\frac{L}{B \times T}\right)$ |
|---|---|---|---|---|---|---|---|---|
| *Lines* | | | | | | | | |
| AS688 | 67.8 | 42.4 | 5.3 | 2.6 | 2.0 | S/B | 2.0 | 1.0 |
| IR25588-7-3-1 | 69.0 | 63.8 | 6.3 | 2.1 | 3.0 | M/M | 1.8 | 1.7 |
| IR28128-45-2 | 66.2 | 59.8 | 6.6 | 1.9 | 3.5 | L/S | 1.6 | 2.2 |
| PND160-2-1 | 64.0 | 47.0 | 6.6 | 1.7 | 3.9 | L/S | 1.6 | 2.4 |
| *Local varieties* | | | | | | | | |
| DR83 | 66.8 | 54.4 | 6.8 | 2.0 | 3.4 | L/S | 1.9 | 1.8 |
| JP5 | 72.8 | 55.2 | 4.9 | 2.8 | 1.8 | S/B | 2.3 | 0.8 |
| KS282 | 69.6 | 58.3 | 7.0 | 2.0 | 3.5 | L/S | 1.8 | 2.0 |

| Entry | Chalky grain (%) | Elongation ratio | Cooked grain appearance[c] | Protein (N × 5.95) % (db) | Amylose (% basis) | Alkali spreading value | Gelatinization temperature[d] (alkali basis) |
|---|---|---|---|---|---|---|---|
| *Lines* | | | | | | | |
| AS688 | 10 | 1.8 | S | 8.3 | 19 | 6.4 | L |
| IR25588-7-3-1 | 6 | 1.5 | S/S | 7.9 | 23 | 5.9 | I |
| IR28128-45-2 | 4 | 1.4 | SE | 8.0 | 25 | 7.0 | L |
| PND160-2-1 | 5 | 1.8 | W/SE | 8.3 | 27 | 7.0 | L |
| *Local varieties* | | | | | | | |
| DR83 | 8 | 1.6 | SE | 8.5 | 22 | 5.2 | I |
| JP5 | 4 | 1.7 | S | 8.6 | 18 | 6.3 | L |
| KS282 | Nil | 2.0 | SE | 8.3 | 28 | 7.0 | L |

[a]Av of 3 replications. [b]S/B = short/bold, M/M = medium/medium, L/S = long/slender. [c]S = sticky, S/S = slightly sticky, SE = separated, W/SE = well separated. [d]L = low, I = intermediate.

# Disease resistance

## Scoring systems for evaluating rice varietal resistance to bacterial blight (BB): lesion size by growth stage

*A. Baw and T. W. Mew, IRRI*

Host plant resistance to pathogens can be measured using different parameters—latent period, pathogen sporulation and growth in host tissues. In most cases, disease symptoms (lesion area, length, etc.) are scored according to an indexing scale based on the assumption that the lesion reflects pathogen growth in the host quantitatively, as a response of the host to infection.

We measured lesion development at different growth stages on 22 rice cultivars grown in pots in the greenhouse and infected with BB isolate PXO61 of race 1.

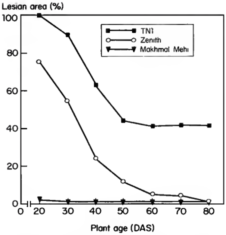
Planting was staggered to synchronize inoculation at different growth stages. Total leaf area was measured using a leaf area meter at 11, 14, and 17 d after inoculation. Lesions were cut from individual leaves, the lesion area measured, and percentage infected leaf area calculated.

The cultivars were classified into three groups. Group 1 (including TN1) was highly susceptible at 20 d after sowing (DAS), but the lesion areas gradually decreased from 30 to 50 DAS and became constant from 50 to 80 DAS (see table). In group 2, lesion area decreased from 20 to 40 DAS but the plants remained susceptible. Lesions

BB lesion development at 11, 14, and 17 d after inoculation on rice cultivars infected with isolate PXO61 of *Xanthomonas campertris* pv. *oryzae* race 1 at different growth stages. IRRI, 1987.

| Plant age (DAS) | Lesion area[a] (%) Group 1[b] | Group 2[c] | Group 3[d] |
|---|---|---|---|
| | | *11 DAI* | |
| 20 | 79.7– 87.7 a | 53.6–55.5 a | 0.8– 4.0 a |
| 30 | 63.8– 69.4 b | 33.9–50.4 a | 0.7– 3.0 a |
| 40 | 27.7– 39.8 c | 21.4–18.4 b | 0.6– 0.9 a |
| 50 | 12.6– 25.6 cd | 8.3– 7.3 b | 0.5– 0.6 a |
| 60 | 10.8– 21.1 cd | 6.8– 6.0 b | 0.4– 0.5 a |
| 70 | 8.2– 16.8 d | 4.0– 5.0 b | 0.4– 0.6 a |
| 80 | 5.1– 18.2 d | 1.0– 3.4 b | 1.2-170 a |
| | | *14 DAI* | |
| 20 | 96.3– 98.7 a | 72.2–85.6 a | 1.5– 7.5 a |
| 30 | 90.1– 92.3 a | 47.6–79.3 a | 1.0– 6.2 a |
| 40 | 50.8– 62.7 b | 28.4–33.9 b | 0.9– 2.1 a |
| 50 | 27.5– 41.6 bc | 12.1–13.3 bc | 0.7– 1.6 a |
| 60 | 20.6– 37.8 c | 9.5–11.0 c | 0.7– 1.5 a |
| 70 | 16.5– 30.7 c | 6.8– 9.3 c | 0.8– 1.4 a |
| 80 | 11.3– 31.5 c | 2.1– 6.4 c | 1.9– 3.0 a |
| | | *17 DAI* | |
| 20 | 99.1–100 a | 82.3–95.5 a | 2.5– 12.2 a |
| 30 | 97.9– 98.1 a | 59.1–92.9 a | 2.2– 9.8 a |
| 40 | 90.9– 79.8 ab | 36.2–51.2 b | 1.3– 3.1 a |
| 50 | 42.7– 58.0 bc | 15.5–20.4 c | 1.0– 2.3 a |
| 60 | 29.7– 50.7 c | 12.1–14.8 c | 1.0– 2.4 a |
| 70 | 26.3– 44.1 c | 9.4–13.7 c | 1.2– 2.3 a |
| 80 | 19.2– 47.1 c | 4.2–11.1 c | 2.5– 3.2 a |

[a]In a column within an inoculation date, values followed by a common letter do not significantly differ at the 5% level. [b]TN1, IR24, RP4-2, IR8, Yolle, M23, IR9101, MTU19. [c]Zenith, Pae Moku, Banda Merah, Ase Pute Rone, Gankkyi, Pasle Angga, Kauk Hayin, Pyi Daw Aye. [d]Ketan Ireng, Warangal Culture 1263, Sankurcha, IR1545, DV85, Makhmal Mehi.




Lesion development in 3 rice cultivars differing in resistance to BB and infected with PX061 of race 1 at different growth stages. IRRI, 1988.

decreased abruptly at 50 DAS, and were less than 5% at 80 DAS. In group 3, lesion area did not exceed 10% even at 20 DAS (see figure).

These results show that even in a susceptible variety, lesion development decreases with plant age. Maximum lesion percentage in a susceptible variety such as TN1, IR8, or IR24 seldom reaches more than 50% of leaf area. This suggests that scoring disease by plant age requires different observation periods. Lesion area in most of the cultivars increased when the plants were younger and decreased as the plants became older. □

## Resistance of rice genotypes to bacterial blight (BB)

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During 1987, we screened 50 entries for BB resistance under field conditions at Fuyang Experiment Station. Entries were transplanted in 2 rows of 12 hills each at 20- × 20-cm spacing. BB-infected Guang Lu Ai 4 and local susceptible check Yuan Feng Zao were transplanted in 1 row between each entry and around the test plot.

Soil was sandy loam with medium fertility. The trial plot was fertilized with 75-37.5-25 kg NPK/ ha. Entries were inoculated from maximum tillering to booting with BB suspension of local predominant isolates collected and isolated from naturally infected leaves, adjusted to a concentration of 6 × $10^8$ cells/ml by leaf tip clipping method.

Of 50 entries screened, 15 were resistant to BB and 27 were moderately resistant (Table 1). BR285-5-6-6-2, B4075D-PN-13-1, RTN904, RP2151-173-1-8, RP2151-21-22, and RP2151-40-

Table 1. Resistance of rice cultivars to 3 isolates of BB 21 d after inoculation. CNRRI, China, 1987.

| Variety, line | Reaction[a] to isolate CN-X12 | CN-X1 | CN-X3 | Origin |
|---|---|---|---|---|
| IR20 | 1 | 1 | 1 | IRRI |
| BR285-5-6-6-2 | 3 | 3 | 1 | Bangladesh |
| BR319-1-HR28 | 3 | 3 | 3 | Bangladesh |
| B4075D-PN-13-1 | 1 | 1 | 1 | Indonesia |
| C731067 | 5 | 5 | 3 | Taiwan, China |
| DV85 | 5 | 5 | 3 | Bangladesh |
| IR29295-70-1-1-1-1-3-1 | 3 | 3 | 3 | IRRI |
| IR33355-39-1-1-3 | 3 | 3 | 3 | IRRI |
| Kalimekri 77-5 | 3 | 3 | 3 | Bangladesh |
| Kogyoko | 5 | 5 | 3 | Japan |
| RP2151-173-1-8 | 1 | 1 | 1 | India |
| RP2151-21-22 | 3 | 0 | 0 | India |
| RP2151-40-1 | 3 | 1 | 1 | India |
| RTN90-4 | 3 | 3 | 3 | India |
| UPR79-80 | 5 | 5 | 3 | India |

[a]BB evaluated by *Standard evaluation system for rice* 0-9 scale.

1 had good resistance to three isolates of BB as well as good agronomic traits and high yield potential.

Reaction of the Guangdong differentials to different isolates of *Xanthomonas campestris* pv. *oryzae* are given in Table 2. On the basis of these reactions. most of the isolates from Fuyang tested so far belong to groups IV, II, and I. Group IV, virulent on China differentials, was often collected from local popularized varieties. BB was scored by the *Standard evaluation system for rice* at 14 and 21 d after inoculation.

**Table 2. Virulence of 3 pathotypes of *X. c.* pv. *oryzae* collected in Fuyang during 1987 on Chinese rice differentials.** [a]

| Isolate | Reaction | | | | | Group |
|---|---|---|---|---|---|---|
| | IR26 | Nongkeng 57 | Zhaiyeqing 8 | Baotaiai | Jinggang 30 | |
| CN-X1 | HR | R | MR | S | HS | 11 |
| CN-X3 | HR | MR | MR | MR | S | I |
| CN-X12 | MR | HS | HS | HS | HS | 1V |

[a] Ratings based on lesion length and mean lesion length for 20 inoculated leaves. SES 0-9 scale. R (resistant) = 1, MR (moderately resistant) = 3, S (susceptible) = 7, HS (highly susceptible = 9.

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## Scoring systems for evaluating rice varietal resistance to bacterial blight (BB): scales for different growth stages

*A. Baw and T. W. Mew, IRRI*

BB lesion development in rice varies by variety and plant growth stage. The scale as well as time of scoring to assess varietal resistance is influenced by plant age. We attempted to formulate a realistic scoring system for BB at different stages of plant growth. Planting and lesion measurement were the same as in the first study.

Our observation showed that lesions on susceptible varieties inoculated at 20 d after sowing (DAS) reached maximum level at 11 d after inoculation (DAI). Inoculation at 30 DAS produced the most lesions at 11-41 DAI; that at 40 DAS, 11-17 DAI; and that at 50 DAS, 17-20 DAI. Actual lesion area, apparent infection rate, and relative area under disease progression curve (ADPC) were analyzed. Final disease ratings and relative ADPCs followed a similar sequence in lesion area. The infection rates, however, did not follow such sequence, compared to actual disease rating or to relative ADPCs.

Final disease ratings and relative ADPCs were further tested to categorize the level of resistance among the test

**Table 1. Varietal resistance to PXO61 of *Xanthomonas campestris* pv. *oryzae,* using different scales at 20 DAS. IRRI, 1988.**

| Variety | Leaf area infected (%) | | Relative ADPC | | SES scale | |
|---|---|---|---|---|---|---|
| | 11 DAI | 14 DAI | 11 DAI | 14 DAI | 11 DAI | 14 DAI |
| RP4-2 | 93.60 | 100.0 | 0.232 | 0.390 | 9 | 9 |
| TN1 | 89.10 | 99.8 | 0.230 | 0.383 | 9 | 9 |
| 59-439 (BII/MAS) | 92.53 | 100.0 | 0.218 | 0.378 | 9 | 9 |
| 6-1 | 89.13 | 98.1 | 0.210 | 0.365 | 9 | 9 |
| IR24 | 87.70 | 98.0 | 0.199 | 0.355 | 9 | 9 |
| Milyang 23 | 88.60 | 98.4 | 0.193 | 0.352 | | |
| CAS209 | 84.30 | 99.2 | 0.193 | 0.348 | 9 | 9 |
| BG94-1 | 82.63 | 96.8 | 0.188 | 0.340 | 9 | 9 |
| Khao Khao Nhay | 78.60 | 90.0 | 0.186 | 0.327 | 9 | 9 |
| MTU18 | 78.90 | 97.7 | 0.181 | 0.332 | 9 | 9 |
| IR8 | 77.77 | 98.7 | 0.179 | 0.330 | 9 | 9 |
| Yakai | 77.87 | 98.6 | 0.175 | 0.327 | 9 | 9 |
| Aneira | 75.40 | 92.4 | 0.169 | 0.313 | | 9 |
| Binirnal | 75.53 | 98.6 | 0.166 | 0.317 | 9 | 9 |
| Pyi Daw Aye | 75.20 | 93.9 | 0.165 | 0.311 | 9 | 9 |
| Kyeearni | 80.07 | 96.0 | 0.165 | 0.318 | 9 | 9 |
| Zenith | 63.10 | 76.3 | 0.155 | 0.274 | 9 | 9 |
| ASE Pute Rono | 58.17 | 76.2 | 0.147 | 0.259 | 9 | 9 |
| Pale Angga | 59.57 | 85.3 | 0.141 | 0.266 | 9 | 9 |
| Yolle | 66.93 | 91.5 | 0.139 | 0.279 | 9 | 9 |
| Kauk Hnyin | 64.50 | 90.7 | 0.137 | 0.274 | 9 | 9 |
| Banda Merah | 62.17 | 78.7 | 0.136 | 0.258 | 9 | 9 |
| Gaukkyi | 51.50 | 85.9 | 0.1 33 | 0.228 | 9 | 9 |
| Ketan Jimbruk | 41.30 | 49.9 | 0.100 | 0.176 | 7 | 7 |
| Pae Moku | 39.60 | 64.2 | 0.091 | 0.183 | 7 | 9 |
| Tahun Gembrong | 33.53 | 39.2 | 0.088 | 0.143 | 7 | 7 |
| Ketan Ireng | 20.30 | 25.5 | 0.055 | 0.092 | 6 | 7 |
| Meegauk | 22.67 | 32.1 | 0.055 | 0.102 | 5 | 7 |
| Akundi | 17.70 | 25.0 | 0.041 | 0.078 | 5 | 5 |
| Warangal Culture 1263 | 14.80 | 23.1 | 0.040 | 0.072 | 5 | 5 |
| Sankurcha | 9.07 | 13.7 | 0.022 | 0.041 | 5 | 5 |
| IR20 | 7.33 | 10.8 | 0.020 | 0.035 | 5 | 5 |
| IR22 | 5.83 | 9.3 | 0.017 | 0.029 | 5 | 5 |
| DZ78 | 6.57 | 13.8 | 0.013 | 0.032 | 5 | 5 |
| AUS40 | 5.13 | 9.0 | 0.012 | 0.024 | 5 | 5 |
| AUS463 | 3.60 | 5.3 | 0.008 | 0.016 | 3 | 3 |
| IR1545 | 3.37 | 4.4 | 0.008 | 0,014 | 3 | 3 |
| AUS338 | 3.57 | 6.3 | 0.008 | 0.016 | 3 | 5 |
| Makhmal Mehi | 1.00 | 1.8 | 0.002 | 0.005 | 3 | 3 |
| DV85 | 0.53 | 1.2 | 0.002 | 0.003 | 1 | 3 |

varieties. A scale for each growth stage was adapted from the Horsfall-Barrett scale based on visual estimation of tissue area infection, widely used in plant pathology. The Horsfall-Barrett scale is based on proportion of disease intensity and has 12 divisions. When it was used to rate disease based on actual lesion area, the score of 1 was excluded.

The modified scale, also based on percent lesion area, has 9 instead of 12 divisions: 1 = 1-3% lesion area, 2 = 4-6%, 3 = 7-12%, 4 =13-25%, 5 = 26-50%, 6 = 51-75%, 7 = 76-87%, 8 = 88-94%, and 9 = 95-100%. It is suitable for scoring disease level at 11-14 DAI on plants 20-30 DAS (Table 1).

At late to maximum tillering (40-50 DAS) final disease ratings and relative ADPCs agree with each other, but not with apparent infection rates. A different scale was developed to score these growth stages at 14-17 DAI: 1 = < 1%, 2 = 1-2%, 3 = 3-4%, 4 = 5-8%, 5 = 9-16%, 6 = 17-32%, 7 = 33-40%, 8 = 41-50%, 9 = > 50%. The modified scale for plants from maximum tillering to maturity also was suitable for evaluating varietal resistance to BB (Table 2).

For the purpose of field screening, the current *Standard evaluation system for rice* (SES) scoring is adequate to distinguish resistance from susceptibility.

**Table 2. Varietal resistance to BB measured by 3 different scales. IRRI, 1988.**

| Variety | Relative ADPC value | Leaf area infected (%) | SES scale | Modified scale (1 to 9) |
|---|---|---|---|---|
| IR910143-6-1 | 0.128 | 45.47 | 7 | 9 |
| TN1 | 0.127 | 44.37 | 7 | 9 |
| IR24 | 0.125 | 42.33 | 7 | 8 |
| MTU18 | 0.110 | 41.90 | 7 | 8 |
| Khao Khao Nhay | 0.108 | 36.50 | 7 | 7 |
| Milyang 23 | 0.107 | 33.43 | 7 | 7 |
| RP4-2 | 0.104 | 34.87 | 7 | 7 |
| IR8 | 0.098 | 30.43 | 7 | 6 |
| Binirnal | 0.084 | 30.43 | 7 | 6 |
| CAS209 | 0.076 | 27.30 | 7 | 6 |
| Aneira | 0.074 | 27.12 | 7 | 6 |
| 59439 (B11/MAS) | 0.065 | 26.80 | 7 | 6 |
| BG94-1 | 0.062 | 24.87 | 5 | 6 |
| Yakai | 0.061 | 24.70 | 5 | 6 |
| Yolle | 0.057 | 21.83 | 5 | 6 |
| Pyi Daw Aye | 0.050 | 18.50 | 5 | 6 |
| Zenith | 0.049 | 12.67 | 5 | 5 |
| ASE Pute Rono | 0.043 | 15.23 | 5 | 5 |
| Pale Angga | 0.043 | 14.23 | 5 | 5 |
| Band Merah | 0.039 | 14.23 | 5 | 5 |
| Kauk Hnyin | 0.031 | 14.80 | 5 | 5 |
| Ketan Jimbruk | 0.030 | 9.20 | 5 | 5 |
| Gaukkyi | 0.027 | 11.40 | 5 | 5 |
| Pae Moku | 0.024 | 9.17 | 5 | 5 |
| Akundi | 0.015 | 5.47 | 5 | 4 |
| Tahun Gembrong | 0.013 | 4.17 | 5 | 3 |
| Warangal Culture 1263 | 0.011 | 4.03 | 3 | 3 |
| Meegauk | 0.1010 | 4.03 | 3 | 3 |
| IR20 | 0.008 | 2.60 | 3 | 3 |
| AUS40 | 0.005 | 2.23 | 3 | 2 |
| Sankurcha | 0.009 | 1.80 | 3 | 2 |
| IR22 | 0.004 | 1.33 | 3 | 2 |
| AUS338 | 0.004 | 1.17 | 5 | 2 |
| DZ78 | 0.004 | 1.33 | 3 | 2 |
| IR1545 | 0.003 | 1.00 | 3 | 2 |
| Makhmal Mehi | 0.003 | 1.00 | 3 | 2 |
| AUS463 | 0.003 | 0.87 | 1 | 1 |
| DV85 | 0.002 | 0.60 | 1 | 1 |

## Sources of resistance to *Pyricularia oryzae* Cav. in Nepal

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Blast epidemics at the seedling stage are frequent in different parts of Nepal. Varieties resistant to *P. oryzae* become susceptible within a few years. To find new sources of resistance, we reviewed varietal reactions in the International Rice Blast Nurseries at Kankai, Parwanipur, Khumaltar, and Palung 1983-85. These locations cover a wide range of climatic conditions (plain, midhill, and high hill).

**Sources of broad-spectrum resistance to *P. oryzae* Cav. in Nepal.**

| Rice line [a] | Donor parents [b] |
|---|---|
| C1322-28 | Tadukan, Sigadis |
| IR7473-118-2-2 | Tadukan, Sigadis, Tetep |
| IR9852-22-3 | Tadukan, Sigadis |
| IR13240-108-2-2 | Tadukan, Sigadis |
| IR17525-278-1-1 [c] | Tadukan, Sigadis |
| IR18348-36-3-3 | Tadukan, Sigadis, Tetep |
| IR18349-22-1-2 | Tadukan, Sigadis |
| IR19672-140-2-3 | Tadukan, Sigadis |
| IR21820-154-3-2 | Tadukan, Sigadis, Tetep |
| IRi 360 | unknown |

[a] All were resistant in Kankai (plain, 1984-85), Parwanipur (plain, 1983-85), Khumaltar (mid-hill, 1983-85), and Palung (high hill, 1983-84). Scoring was done according to the Standard evaluation system for rice scale of 0-9: 0-2 = resistant (R). [b] Extracted from *Parentages of IRRI crosses, IRI to IR50,000.* [c] Data not available for Parwanipur, 1985.

Disease pressure was high at all locations. A large number of rice lines exhibited resistance reaction in 1 or 2 tests, but only 10 lines were resistant in 2 to 3 yr at all sites (see table). Nine were progeny of Tadukan, Sigadis, and Tetep. These donor parents also exhibited resistance at all test sites.

Changes in disease reaction of several international differentials indicate the existence of different physiological races of the blast pathogen and unstable resistance in released varieties. Some of the lines identified that have desirable agronomic traits might be sources of resistance to control leaf blast epidemics at the seedling stage. □

## Screening rice germplasm against Fusarium sheath rot (ShR) disease

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We screened 34 cultivars and lines against the Fusarium ShR organism *Fusarium moniliforme* Sheld. in the field and in the pot house under artificial inoculation. A spore suspension of the pathogen was sprayed to injured boot leaf sheaths in the pot house and to uninjured boot leaf sheaths in the field.

Disease severity was scored on a 0-4 scale:
0 = no infection; 1 = small brown lesions on boot leaf sheath, some lesions enlarge and coalesce to cover about 25% of the leaf sheath, normal panicle emergence and grain filling; 2 = lesions cover about half the sheath with incomplete panicle exsertion, glumes discolored, sterile spikelets; 3 = lesions cover 65% of sheath, panicle struggles to emerge, more than 50% sterile spikelets, severe glume discoloration; and 4 = entire sheath rotted, no panicle emergence, or if panicle emerges, no grain filling.

Cultivars or lines that showed no disease in the field were infected in the pot house (see table). None of the cultivars or lines tested were immune, but disease severity in the pot house was lowest in the lines that showed no infection in the field. Even though most lines or cultivars were infected, panicle emergence and grain filling were normal. Some high-yielding cultivars (Jaya and PR106) were most susceptible.□

**Reaction of rice cultivars or lines to** *F. moniliforme.* **Ludhiana, India, 1985-86.**

| Mean disease severity score | Cultivar or lines | |
|---|---|---|
| | Field | Pot house |
| 0 | 1254, 1255, 1259, 1272, 1326, 1336, Bas. 370, Pb. Bas. 1 | – |
| 0-1 | 1168, 1169, 1170, 1173, 1175, 1180, 1195, 1197, 1201, 1202, 1203, 1204, 1210, 1213, 1249, 1253, 1337, 1352, 1353, PR4141, PR103, IR8 | 1168, 1169, 1170, 1180, 1195, 1197, 1202, 1203, 1204, 1210, 1213, 1245, 1249, 1253, 1254, 1255, 1259, 1272, 1326, 1336, 1337, 1352, 1353, PR4141, PR103, Bas. 370, Pb. Bas. 1, IR8 |
| 1-2 | 1245, Palman 579, Jaya | 1175, 1201, Palman 579 |
| 2-3 | – | 1173, Jaya |
| 3-4 | PR106 | PR106 |

## Background resistance to bacterial blight (BB): lesion expansion

*C. M. Vera Cruz and T. W. Mew, IRRI*

A cultivar's background resistance to BB can be demonstrated indirectly by comparing its relative resistance index to races 1 and 2 of *Xanthomonus campestris* pv. *oryzae*. The index was determined from hill and leaf infection of IR cultivars compared to susceptible check IR24.

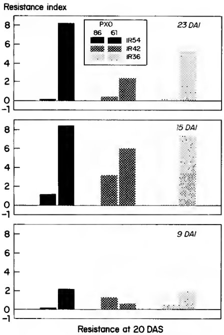
We analyzed lesion expansion on infected leaves as an indicator of background resistance. Component measurements may show differences in resistance among IR cultivars possessing the *Xa-4* gene. Six races of the BB pathogen and IR20, IR22, IR26, IR36, IR42, IR48, IR54, IR58, and IR62, all known to carry *Xa-4,* were examined.

Plants were raised in pots in the greenhouse, with two replications/ cultivar arranged in a split-split-plot design. Plantings were staggered at 20-d intervals to synchronize inoculation.

**Resistance or susceptibility to BB of IR cultivars on the basis of mean lesion area at 15 d after inoculation. Expressed in relation to resistance of susceptible check IR24[a] to virulent and avirulent races of *X. c.* pv. *oryzae.***

| Variety | Relative resistance[b] (%) | | | | | |
|---|---|---|---|---|---|---|
| | Avirulent race | | | Virulent race | | |
| | PXO61 | PXO112 | PXO71 | PXO86 | PXO79 | PXO99 |
| | | | *20 DAS* | | | |
| IR26 | 66.3 a | 45.2 a | 51.1 a | 0.4 b | 2.6 a | 0.0 a |
| IR22 | 63.6 ab | 34.9 a | 7.5 c | 0.0 b | –14.2 a | 0.5 a |
| IR20 | 62.9 ab | 40.6 a | 18.9 abc | 2.3 b | –6.1 a | 5.1 a |
| IR54 | 61.8 ab | 52.7 a | 44.5 ab | 20.8 ab | 7.8 a | 1.7 a |
| IR58 | 61.2 ab | 41.2 a | 37.8 abc | 3.9 b | –3.4 a | 0.0 a |
| IR48 | 60.1 ab | 40.0 a | 40.2 abc | 42.8 a | 4.7 a | 0.7 a |
| IR36 | 51.2 ab | 40.9 a | 10.0 bc | –0.2 b | –8.1 a | 0.0 a |
| IR42 | 48.9 ab | 43.4 a | 16.5 abc | 23.3 ab | –0.4 a | 0.5 a |
| IR62 | 27.4 b | 39.9 a | 25.3 abc | 18.0 ab | 3.8 a | 0.0 a |
| | | | *40 DAS* | | | |
| IR54 | 40.9 a | 28.1 a | 29.7 ab | 12.4 a | 2.0 a | 26.8 a |
| IR26 | 37.8 a | 26.1 a | 37.4 a | –0.9 ab | –1.6 a | 15.3 ab |
| IR20 | 36.9 a | 23.1 a | 23.1 abc | 3.8 ab | –2.4 a | 12.6 ab |
| IR58 | 36.4 a | 17.7 a | 27.3 abc | 7.7 ab | –6.6 a | 5.7 bc |
| IR22 | 35.2 a | 23.5 a | 34.4 a | –2.4 b | –0.1 a | 15.6 ab |
| IR48 | 35.1 a | 23.2 a | 13.8 bc | 10.5 ab | 3.6 a | 12.5 ab |
| IR42 | 34.4 a | 27.9 a | 13.6 bc | 6.5 ab | –4.4 a | 6.8 ab |
| IR36 | 34.4 a | 20.8 a | 20.3 abc | –3.6 b | –5.1 a | 10.1 bc |
| IR62 | 31.8 a | 20.9 a | 11.5 c | –0.1 ab | –8.4 a | –2.2 c |
| | | | *60 DAS* | | | |
| IR54 | 19.5 a | 19.8 a | 19.3 a | 11.4 a | 7.5 a | 20.7 a |
| IR26 | 19.5 a | 19.4 a | 18.7 a | 0.2 a | –1.2 a | 14.9 ab |
| IR22 | 19.5 a | 20.2 a | 13.3 a | –0.6 a | 3.1 a | 8.4 ab |
| IR58 | 18.7 a | 19.4 a | 14.5 a | –0.4 a | –0.1 a | 7.7 b |
| IR48 | 17.5 a | 15.4 a | 12.2 a | 6.1 a | 7.9 a | 11.6 ab |
| IR36 | 17.1 a | 13.5 a | 9.5 a | –2.4 a | –3.3 a | 4.3 b |
| IR62 | 16.6 a | 18.4 a | 7.3 a | –0.1 a | –2.4 a | 11.6 ab |
| IR42 | 16.2 a | 16.2 a | 9.9 a | –1.3 a | 0.9 a | 10.3 ab |
| IR20 | 13.4 a | 15.6 a | 16.0 a | 4.0 a | 4.1 a | 8.4 ab |

[a]Estimated on basis of lesion area. [b]0 = as susceptible as IR24, + = more resistant, – = more susceptible. In a column, treatment means for each DAS having a common letter are not significantly different by DMRT at the 5% level.




Resistance of IR varieties to race 1 (PXO86) and race 2 (PXO61) of *Xanthomonas campestris* pv. *oryzae.* Index based on resistance of IR24 0-9 d after inoculation. + = more resistance than IR24, - = more susceptible than IR24.

Three races — PXO86, PXO79, PXO99—virulent on cultivars carrying *Xa-4,* and 3 avirulent races—PXO61, PXO112, and PXO71—were used to inoculate plants at 20, 40, and 60 d after sowing (DAS). IR24, which is not known to carry *Xa-4,* was the susceptible check.

Lesion areas were estimated at 9, 15, and 23 d after inoculation (DAI) and converted to a relative resistance index (RI) based on the lesion area of IR24. (The estimation of RI based on lesion area was similar to that based on hill or leaf infection.) Here, RI is an indication of lesion expansion across time after initial infection.

The IR cultivars showed high relative resistance to the three avirulent races (see table). To the virulent races that matched gene *Xa-4,* relative resistance was low. In all cases, the virulence × resistance index interaction was not significant, apparently indicating that background resistance does not interact with race.

RI for PXO61, avirulent to *Xa-4* and PXO86, virulent, were compared to determine the effect of *Xa-4* and the corresponding background resistance on selected IR cultivars. By 20 DAS, *Xa-4* had shown its effect, as indicated by high RI to PXO61 (see figure). Background resistance was indicated by RI unmatched by PXO86. At 40 and 60 DAS, lesions ceased to expand. RI values decreased because of the susceptible check cultivar.

Lesion expansion may be a better parameter to detect the effect of both *Xa-4* and background resistance at an early stage. Such measurements may provide an accurate assessment of background resistance, as the variance seems to be small. The data also indicate that lesion expansion varies among cultivars.

Our studies also indicate that IR24 may not be the most appropriate susceptible check. If a more susceptible cultivar were used, the difference might be more evident and the background resistance more accurately distinguished. □

# Insect resistance

## ACM18 (IET7804), a high-yielding gall midge (GM)-resistant rice

*S. Sevugaperumal, G. Logiswaran, S. Jebaraj, G. Soundrapandian, and P. C. Sundara Babu, Agricultural College and Research Institute, Madurai 625104, Tamil Nadu, India*

We evaluated 13 rice cultivars against susceptible and resistant checks for yield potential and reaction to GM in the field. The experiment was in unprotected conditions with 2 replications in 4.8-m$^2$ plots. Seedlings were transplanted at 28 d on 20 Oct 1986, late in the season to capture a high pest population buildup. Susceptible IR20 was planted around the experimental plots to ensure adequate pest pressure.

Damage by GM was estimated as percentage of plants affected and % silvershoots at 50 d after transplanting (DT) and graded according to the *Standard evaluation system for rice* (SES) scale. Days to 50% flowering and yield were also recorded.

ACM18 (IET7804), a cross derivative of OR158-5/Rasi, had the lowest GM incidence (2.23%), followed by IET9690, Surekha, and IET9688 (Table 1). ACM18 had the highest grain yield (5.3 t/ha in 120 d), 32.5% more than that of IR20 and 10 d earlier.

**Table 1. Reaction to GM and yield of 15 rices. Tamil Nadu, India, 1986.**

| Culture | 50 DT[a] | | | | | Days to 50% flowering | Grain yield (t/ha) | % of IR20 |
|---|---|---|---|---|---|---|---|---|
| | Plants damaged (%) | | Silvershoots (%) | | Infestation score[b] | | | |
| ACM18 (IET7804) | 0.33 | (0.88) | 2.23 | (1.37) | 3 | 90 | 5.3 | 132.5 |
| IET8629 | 4.50 | (2.23) | 11.10 | (3.39) | 5 | 75 | 4.6 | 115.0 |
| IET8633 | 1.90 | (1.52) | 11.56 | (3.48) | 5 | 75 | 3.8 | 95.0 |
| IET8803 | 9.60 | (3.10) | 10.56 | (3.32) | 5 | 77 | 3.6 | 90.0 |
| IET9234 | 8.66 | (3.01) | 10.93 | (3.38) | 5 | 100 | 3.1 | 77.5 |
| IET9247 | 2.40 | (1.67) | 9.03 | (3.07) | 5 | 95 | 2.5 | 62.5 |
| IET9587 | 3.50 | (1.98) | 10.93 | (3.36) | 5 | 85 | 5.1 | 127.5 |
| IET9688 | 0.30 | (0.87) | 4.76 | (1.76) | 3 | 99 | 2.9 | 72.5 |
| IET9689 | 1.50 | (1.41) | 10.30 | (3.26) | 5 | 82 | 4.9 | 122.5 |
| IET9690 | 0.60 | (0.98) | 2.76 | (1.46) | 3 | 76 | 4.6 | 115.0 |
| IET9692 | 4.63 | (2.26) | 10.83 | (3.36) | 5 | 89 | 4.1 | 102.5 |
| IET9695 | 3.00 | (1.85) | 9.16 | (3.09) | 5 | 100 | 1.3 | 32.5 |
| IET9699 | 3.30 | (1.94) | 10.33 | (3.24) | 5 | 74 | 4.4 | 110.0 |
| Surekha (resistant check) | 0.60 | (1.02) | 4.03 | (1.94) | 3 | 90 | 5.1 | 127.5 |
| IR20 (susceptible check) | 11.86 | (3.51) | 12.56 | (3.62) | 5 | 100 | 4.0 | 100.0 |
| LSD (0.05) | (0.65) | | (1.15) | | – | – | 0.9 | – |

[a] Figures in parentheses are transformed values. [b] By SES.

**Table 2. Results of artificially inoculating rices with GM. Tamil Nadu, India, 1986.**

| Rice | Tillers (no./hill) | GM-affected tillers (no./hill) | Affected tillers (%) | Infestation score |
|---|---|---|---|---|
| ACMI8 (IET7804) | 15 | 0 | 0.0 | 0 |
| IET9688 | 17 | 3 | 17.6 | 7 |
| IET9690 | 12 | 2 | 16.7 | 7 |
| IR20 (susceptible check) | 14 | 6 | 42.9 | 7 |
| Surekha (resistant check) | 13 | 1 | 7.7 | 5 |

The same three rices were tested under artificial conditions. Five unemerged galls were introduced into each caged plant. After 25 d, percentage of affected tillers was 7.7 in resistant check Surekha, 42.9 in susceptible check IR20, and 0 in ACM18 (Table 2). □

## Screening rice varieties with different growth durations for spider mite *Oligonychus oryzae* infestation

*A. Prakash, J. Rao, and D. C. Asthana, Central Rice Research Institute, Cuttack 7.53006, India*

Sixteen rice varieties with short, medium, and long growth durations were transplanted in 4- × 4-m plots in the field during 1986 wet season. An aqueous suspension of spider mite *O. oryzae* containing 100 adults/250 ml water was sprayed on rice foliage 10 d after transplanting.

Severe mite infestation 40 d after spraying caused yellowing. Mite populations (eggs, juveniles, and adults) were recorded from a 10 $cm^2$ leaf area on 10 hills/plot chosen at random.

No test variety was free from mite infestation (see table). The mite population was highest in long-duration CR1018 and lowest in short-duration Subhadra. Within the same duration group, some varieties showed significantly different populations. Population differences were not significant between all varieties of one duration and all varieties of another duration. □

**Spider mite populations in rice varieties of different growth durations. Cuttack, India, 1986 wet season.**

| Variety | Parents | Duration[a] (d) | Mites[b] (no./10 $cm^2$) |
|---|---|---|---|
| Subhadra | TNl/SR26-13 | 90 S | 18.9 a |
| Bala | N22/TN1 | 105 S | 20.4 a |
| Kalinga-II | AC540/Ratna | 80 S | 28.2 b |
| Vani | IR8/CR1014 | 125 M | 28.9 b |
| Parijat | TKM6/TN1 | 115 M | 30.0 b |
| Kesari | Kumar/Jagannath | 95 S | 30.6 b |
| Sattari | Mut-Sel (NSJ200/Padma) | 70 S | 32.6 b |
| Pankaj | Peta/Tonkai Rotan | 145 L | 34.0 b |
| Savitri | Pankaj/Jagannath | 155 L | 39.6 c |
| Utkal Prabha | Waikoku/CR1014 | 155 L | 40.5 c |
| Karuna | IR8/Adt 27 | 125 M | 47.8 d |
| Jaya | T141/TN1 | 130 M | 50.8 d |
| Jagannath | T141 mutant | 150 L | 53.4 d |
| Ratna | TKM6/IR8 | 125 M | 60.2 e |
| Vijaya | T90/IR8 | 140 L | 62.8 e |
| CR1018 | Culture | 155 L | 70.5 f |

[a]S = short duration, M = medium duration, L = long duration. [b]Mean of 3 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

## Leaffolder (LF) epidemic in Haryana

*K. S. Kushwaha, Haryana Agricultural University (HAU), Rice Research Station (RRS), Kaul (Kurukshetra), Haryana, India*

Rice LF *Cnaphalocrocis medinalis* historically has occurred only as a sporadic and minor rice pest. But during the 1987 wet season (kharif), it struck in an epidemic intensity. Karnal, Kurukshetra, Ambala, and Sirsa districts were badly damaged.
Infestation started the first week of Aug and lasted to the first week of Oct. Peak infestation was during the second week of Sep, when the rice crop was at the booting to panicle emergence stage. No variety was untouched, but varieties with relatively broader leaves had less infestation. The pest caused 30-80% yield loss.

**LF damage on rice in Haryana, India, 1987.**

| Variety | Tillers/hill[a] | | | Leaves/hill[b] | | | Length/leaf | | | Larvae |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Affected | % | No. | Folded | % | Length (cm) | Length affected (cm) | % | (no./10 leaves) |
| Jaya | 8.3 | 5.8 | 70 | 44.2 (6.72) | 30.5 (5.31) | 47 | 46.4 | 9.4 | 20 | 12.2 |
| HKR120 | 10.3 | 10.1 | 98 | 51.7 (7.14) | 51.5 (7.22) | 100 | 37.2 | 19.0 | 50 | 18.2 |
| PR106 | 8.9 | 8.6 | 97 | 44.5 (6.74) | 42.8 (6.62) | 96 | 42.4 | 24.6 | 58 | 13.5 |
| IET8113 | 9.7 | 8.6 | 89 | 48.4 (6.96) | 36.1 (6.00) | 78 | 40.6 | 19.1 | 78 | 14.7 |
| IET8116 | 12.3 | 11.0 | 98 | 51.2 (7.21) | 36.2 (6.01) | 85 | 39.6 | 15.6 | 62 | 15.7 |
| Pakistan Basmati | 14.4 | 14.4 | 100 | 67.2 (8.26) | 66.0 (8.19) | 100 | 71.9 | 60.6 | 84 | 52.0 |
| LSD (0.05) | 2.8 | 4.0 | | (0.60) | (1.75) | | 9.3 | 4.7 | | 4.7 |

[a]Av of 20 hills. [b]Av of 20 leaves. Figures in parentheses are $\sqrt{n+1}$ values.

LF damage, affected tillers/ hill, folded leaves/ hill, affected length/ leaf, and larvae/10 leaves on 6 varieties were collected at HAU RRS during the second week of Sep 1987, when the attack was at its peak. Average temperature during this period was 22.8-35.6 °C, humidity was 50-79%.

Jaya had minimum LF damage, Pakistani Basmati showed highly susceptible reaction to attack (see table). Medium-statured varieties in general had only 1 or 2 larvae/leaf; Pakistani Basmati averaged 5-6 larvae/ leaf. Almost the whole leaf length (84%) in Pakistani Basmati was affected, compared to 20 to 78% in dwarf varieties. All leaves were damaged on HKR120, PR106, and Pakistani Basmati. □

## Varietal reaction to rice whorl maggot (RWM) *Hydrellia philippina* Ferino

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Remarkable differences in RWM damage were observed among 52 rice lines derived from 19 crosses and the check IR50 in the Cold Tolerant Variety Breeding Trial during 1985 dry season.

Each cultivar was transplanted in irrigated wetland in a 7-m$^2$ plot with 4 replications. Recommended agronomic practices were followed. No insecticide was applied to 60 d after transplanting (DT). RWM damage was estimated as total and damaged leaves in 10 plants randomly selected from each replication at 40 DT.

Eleven lines were found promising, with 10% or less damaged leaves (see table). The most promising were RP2418-5, RP2418-10, and RP2419-3 with 3-5% damaged leaves. In promising lines, leaf damage ranged from 3.9 to 10.8%; highest was 46.4% in RP2235-200 (Phalguna/IR50). These lines are also cold tolerant. □

**Reaction of rice cultures to RWM at DDR, Hyderabad, India.**

| Cultivar | Cross | Transformed means[a] (angular trans.) |
|---|---|---|
| RP2418-5 | Ratna/Zagar | 11.45 (3.9) |
| RP2419-3 | IR36/Larbeoul | 12.11 (4.5) |
| RP2418-10 | Ratna/Zagar | 12.90 (5.1) |
| RP2414-7 | K39/VL 8 | 14.11 (6.0) |
| RP2415-7 | IR36/IC47321 | 13.61 (6.0) |
| RP2419-2 | IR36/Larbeoul | 16.22 (8.1) |
| RP2418-4 | Ratna/Zagar | 17.74 (9.3) |
| RP1842-3 | Jukoku/Rasi | 18.51 (10.1) |
| RP1842-2 | Jukoku/Rasi | 18.62 (10.5) |
| RP2199-9 | Phalguna/TKM6 | 18.83 (10.6) |
| RP2418-1 | Ratna/Zagar | 19.17 (10.8) |
| RP2235-200 | Phalguna/IR50 | 42.93 (46.4) |
| IR50 (check) | – | 24.65 (17.4) |
| Mean | | 18.53 |
| LSD (0.05) | | 3.55 |
| CV (%) | | 13.40 |

[a]Figures within parentheses indicate the mean values of percentage damaged leaves over 4 replications.

# Excess water tolerance

## CR 1009: suitable variety for waterlogged conditions

*T. Sundaram, O. R. Pillai, S. Sevugaperumal, J. G. Robinson, and A. S. Mathar, Agricultural Research Station, Thirupathisaram 629901, Tamil Nadu, India*

In Kanyakumari district, particularly in Kalkulam and Vilavancode Taluks, rice is cultivated under waterlogged conditions in 7,000 ha. Local long-duration varieties Thattaravellai, Vallarakkan, Valsiromundan, and Saradi are low yielders, tall and thin stemmed, and prone to lodging.

**Yield (t/ha) of four varieties under waterlogged conditions in nine locations. Tamil Nadu, India.**

| Variety | Duration (d) | Plant ht (cm) | Grain yield (t/ha) Mean | Grain yield (t/ha) Range |
|---|---|---|---|---|
| CO 42 | 132 | 90 | 5.3 | 3.1-6.7 |
| Ponni | 141 | 110 | 4.0 | 2.5-5.2 |
| IET5656 | 132 | 94 | 5.2 | 3.4-6.6 |
| CR1009 | 150 | 94 | 6.0 | 5.0-8.1 |
| LSD (0.05) | – | – | 0.6 | – |

We tested CO 42, Ponni, IET5656, and CR1009 in nine locations in farmers' fields. CR1009 (Pankaj/Jagannath) recorded significantly higher mean grain yield, with a maximum of 8.1 t/ha (see table). It is 94 cm high, matures in 150 d, and has short bold white grains. □

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# Adverse temperature tolerance

## Varietal screening for cold tolerance

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Rainfed rice cultivation in Sikkim extends from 300 m to 2,000 m. In general, 80% or more of the rice area is occupied by local traditional varieties with good grain quality, blast resistance, and cold tolerance. They are of long duration and have low yields. The season for transplanting depends on the onset of the monsoon. Improved varieties that have been adopted are of short duration with high yields and average grain quality, but are not cold tolerant.

Improved varieties DR92, Rassi, and Prasad were compared with local varieties Thapachine, Krishanbhog, Champasare, Tulasi, Dutkati, and Sarju 49 for cold tolerance under field and glasshouse conditions. Average minimum temperature after 15 Nov was 8-14 °C under both conditions. In addition, tap water irrigation at 5-10 °C was given in the glasshouse.

Low temperature and cold water were observed to affect spikelet emergence and development. Chlorophyll degradation was also observed.

Pollen production and pollen viability were much higher in traditional varieties than in improved varieties (see table). Chlorophyll degradation was also faster in cold-susceptible cultivars. Low water temperature in the glasshouse resulted in lower pollen count and viability. □

**Pollen production and viability in some rice varieties under cold temperature. Sikkim, India.**

| Genotype | Field condition | | Glasshouse condition | | Normal condition[a] |
|---|---|---|---|---|---|
| | Pollen count | Viability (%) | Pollen count | Viability (%) | Viability (%) |
| Sarju 49 | Very low | 33.5 | Very low | 3.9 | 82.9 |
| DR92 | Very low | 40.7 | Very low | 22.4 | 92.5 |
| Prasad | Very low | 35.5 | Very low | 15.7 | 67.8 |
| Rassi | Very low | 35.7 | Very low | 15.5 | 80.4 |
| Thapachine | Low | 50.7 | Low | 38.8 | 82.2 |
| Krishanbhog | Low | 45.5 | Low | 35.6 | 84.4 |
| Champasare | Low | 49.5 | Very low | 28.7 | 85.8 |
| Dutkati | Low | 50.0 | Very low | 28.5 | 78.7 |
| Tulasi | Average | 60.7 | Low | 48.9 | 90.3 |
| Khosaro | Low | 34.6 | Very low | 12.7 | 84.7 |

[a]Pollen count was normal.

## Screening rice varieties for cold tolerance at early seedling stage

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In the hill zone of North India, about 1.8 million ha of rice is exposed to low temperature damage at different growth stages. The Mar- or Apr-sown crop in the medium and higher altitudes and the boro crops in the West Bengal and Assam plains suffer from low temperature damage at sowing and early seedling stages.

We screened 11 promising indica varieties for cold tolerance at the early seedling stage. In the procedure, 50 uniform seeds of each variety were soaked in water for 24 h in petri dishes, drained, washed thoroughly with distilled water, then covered with moist paper towels and kept at room temperature for 3 d. Germinated seeds were submerged in water in petri dishes and refrigerated at 4 °C for 10 d.

After 10 d the petri dishes were removed from the refrigerator. The seeds were kept at room temperature for 1 d, placed in sunlight for 5 d, then scored for cold tolerance.

**Cold tolerance at early seedling stage of 11 indica rice varieties in North India hills.**

| Variety | Seedling survival (%) | Cold tolerance score[a] |
|---|---|---|
| VL 191 | 87 | 3 |
| T3 | 76 | 3 |
| Mahsuri | 76 | 3 |
| VL 206 | 68 | 5 |
| Rasi | 67 | 5 |
| IR8 | 60 | 5 |
| Govind | 37 | 7 |
| UPRI 82-42 | 7 | 7 |
| Pant Dhan 4 | 6 | 7 |
| Saket 4 | 0 | 9 |
| Prasad | 0 | 9 |

[a]1 = all seedlings with green leaves, 3 = less than 30% of seedlings dead, 5 = 30-50% of seedlings dead, 7 = more than 50% seedlings dead, and 9 = all seedlings dead.

No variety was completely tolerant. T3, Mahsuri, and VL 191 scored 3 (see table); however, T3 and Mahsuri are not suitable for hill planting because of their long duration (135 d). VL 206, recommended for Mar or Apr sowing in the hills, and Rasi and IR8 scored 5. Other varieties had poor seedling survival. □

# Adverse soils tolerance

## Sensitivity of rice seedlings to salinity

*M. Akhar and D. Senadhira, IRRI*

We experimented to determine the age at which rice seedlings are most sensitive to salinity, using salt-tolerant varieties Nona Bokra and Pokkali and salt-sensitive IR28 and IR2035-117-3.

Pregerminated seeds were sown on Styrofoam sheets, each with 60 holes and a nylon net bottom, at one seed/hole, 60 seeds/variety. The sheets were floated in 40- × 20- × 15-cm plastic trays filled with 9 liters nutrient solution N maintained at pH 5.0. Seedlings were grown at 29/21 °C (day/night) with about 70% relative humidity in the phytotron glasshouse under natural daylight.

Salinity stress of 6,800 ppm (EC 12 dS/m) was introduced by adding 1:1 mixture of NaCl and $CaCl_2$ to the nutrient solution at 4, 5, 6, 7, 8, 9, 10, 11, and 12 d after seeding. Unsalinized trays of each variety were the checks. Seedling survival was measured 14 d after salinization.

Survival of unsalinized checks of all varieties was 100%. Salt-tolerant Nona Bokra and Pokkali were not affected by salinity (see table). Seedlings of sensitive variety IR28 were severely affected up to 7 d, then gradually gained tolerance. IR2035-117-3 seedlings showed sensitivity up to 6 d. Varietal differences in salt sensitivity were apparent. Tolerance in sensitive varieties increased with age, showing that seedling age is a critical factor in screening for salt tolerance. □

**Rice seedling survival after 14 d salinization (EC = 12 dS/m) pressure applied at different seedling ages. IRRI, 1988.**

| Variety | Survival (%) at each seedling age (d) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Nona Bokra | 100 | 100 | 100 | 98 | 96 | 100 | 100 | 100 | 100 |
| Pokkali | 82 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| IR28 | 2 | 17 | 12 | 20 | 70 | 70 | 97 | 100 | 100 |
| IR2035-117-3 | 10 | 52 | 57 | 85 | 93 | 92 | 98 | 100 | 100 |

## Performance of some acid tolerant rice varieties in two acid saline soils of Sunderbans

*A. K. Bandyopadhyay, Central Soil Salinity Research Institute, Regional Research Station Canning, Canning Town, 24-Parganas(S), West Bengal, Pin: 743329 India*

We transplanted 51 promising acid tolerant rice varieties and lines collected from Indonesia, West Africa, Thailand, Sri Lanka, Malaysia, Philippines, India, and IRRI in acid saline soils of Nirdeshkhali (ECe 9.3-5.4 dS/m and pH 3.3-3.8) and Belakhali (ECe 4.0-3.0 dS/m, pH 5.0-5.8).

In the highly acid saline soils of Nirdeshkhali, the highest grain yields were from IR28222-9-2-2-2-2, and RD15 (see table). In less acidic conditions, RD15 gave the highest yield, followed by SR26B and IR28222-9-2-2-2-2.□

**Grain yield of promising acid tolerant rice varieties. Sunderbans, India, 1987.**

| Variety, line | Grain yield (g/plant) | |
|---|---|---|
| | Nirdeshkhali | Belakhali |
| IR28222-9-2-2-2-2 | 8.9 | 14.0 |
| RD15 | 8.1 | 20.8 |
| S4 | 6.9 | 8.3 |
| Gablak - Cablal | 6.9 | 7.4 |
| IET230 | 6.9 | 8.6 |
| S3 | 6.7 | 8.6 |
| IR8067-41-IE-P1 | 6.7 | 12.2 |
| BW100 | 6.7 | 10.8 |
| Quisidugo | 6.0 | 5.8 |
| B2443B-KN-10-1-1-1 | 5.9 | 11.4 |
| B221496-pn-26-1-1 | 5.5 | 12.3 |
| SR26B | 5.5 | 14.8 |
| S5 | 5.5 | 13.5 |
| S1 | 5.5 | 12.6 |
| Jaca | 5.5 | 10.1 |
| ITA-116 | 5.5 | 5.0 |

# Integrated germplasm improvement

## ADT39, a new rice variety for Tamil Nadu

*P. Parthasarathy, R. Vaithilingam, W. W. Manuel, S. Vairavan, N. Nadarajan, V. Sivasubrumanian, and S. Chelliah, Tamil Nadu Rice Research Institute, Aduthurai, India*

ADT39 is a derivative of IR8/IR20 made in 1976. It is a nonlodging semidwarf with 120- to 125-d duration and medium slender white rice.

Good grain yields were recorded in research station, All India Coordinated

**Yield of ADT39 in Tamil Nadu, India.**

| Test | Grain yield (t/ha) | | Increase (%) |
|---|---|---|---|
| | ADT39 | IR20 | |
| TRRI, Aduthurai | 4.8 | 4.1 | 17 |
| AICRIP trials (wet season) | 3.8 | 3.3[a] | 15 |
| AICRIP trials (dry season) | 5.1 | 4.5[a] | 13 |
| Adaptive research trials (Thanjavur district) | 5.6 | 4.9 | 14 |
| Crop cutting experiments (Thanjavur district) | 6.3 | 4.5 | 40 |

[a] Jaya.

Rice Improvement Project (AICRIP), and adaptive trials and in crop cutting experiments in farmers' fields.

Yield increase was 14-40% compared with IR20 and 13-15% compared with Jaya (see table). In AICRIP trials, it was superior to Jaya at six locations during the wet season and two locations during the dry season.

ADT39 is resistant to bacterial blight, blast, neck blast, brown spot, sheath blight, and grain discoloration; moderately resistant to green leafhopper; and susceptible to sheath rot, leaffolder, and brown planthopper. (However, BPH is not a problem in the season in which it is grown.)

ADT39 has 65% milling recovery and 10.1% protein. The fine-grained rice cooks well and is highly preferred in South India. Farmers of Tamil Nadu have named it "Idly rice" and "tiffin rice." The Agricultural Department estimated its natural spread, before release, in 40,000 ha in Thanjavur district.

ADT39 is already proven well suited to late planting (Oct-Nov) in Thanjavur district. Because it matures earlier than IR20, it should escape water scarcity during ripening, opening room for timely sowing of black gram, green gram, and cotton in the rice fallow season. □

## VL Dhan 163 - a new upland rice variety for Uttar Pradesh hills

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VL Dhan 163, a derivative of IR5904, was released in 1987 for upland Jun sowing in the U.P. hills.

VL Dhan 163 possesses such desirable characteristics as semitall stature, medium grain, and compact panicle with good spikelet fertility. It has moderate tillering ability and matures in 108-113 d. It is tolerant of drought and low temperature and shows good response up to 60 kg N/ha. It also has shown high resistance to leaf and neck blast, stem borer, and leaffolder (see table).

In 12 trials at different sites in the U.P. hills, VL Dhan 163 produced an average 2.6 t/ha, 41.35% higher than the national check Bala.

Traditionally, the hill farmers of U.P. grow Mar- or Apr-sown spring rice under rainfed upland conditions in a 2-yr cropping system of spring rice - wheat - finger millet - fallow. With VL Dhan 163, hill farmers will be able to plant two rice crops in a year. □

**Plant characteristics of VL Dhan 163 and Bala. Almora, U. P., India, 1987.**

| Character | VL Dhan 163 | Bala (check) |
|---|---|---|
| Plant height (cm) | 95-100 | 65-70 |
| Days to 50% flowering | 75-80 | 80-85 |
| Days to maturity | 108-113 | 105-110 |
| 1000-grain weight (g) | 19.0 | 16.0 |
| Hulling percentage | 85.4 | 83.7 |
| Grain length (mm) | 5.4 | 4.6 |
| Grain width (mm) | 2.2 | 2.4 |
| Length/width ratio | 2.4 | 1.9 |
| Protein content | 9.3 | 9.0 |
| Yield (t/ha) | 2.6 | 1.8 |
| *Disease & insect pest reaction*[a] | | |
| Leaf blast (0-9 scale) | 3 | 9 |
| Neck blast (0-9 scale) | 1 | 9 |
| Sheath rot (0-9 scale) | 3 | 7 |
| False smut (0-9 scale) | 1 | 5 |
| Stem borer (0-9 scale) | 3 | 5 |
| Leaffolder (0-9 scale) | 1 | 5 |

[a]By *Standard evaluation system for rice.* Maximum score recorded during any year 1983-86.

## Performance of semidwarf mutants of Basmati 370

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Four semidwarf mutants (gamma radiation 25 kR) were selected from the segregating population and yield tested in the field. The short-statured mutants gave significantly higher grain yields than parent variety Basmati 370 and had high tillering ability (Table 1) and lodging resistance. Growth duration was similar to Basmati 370. The semidwarf

**Table 1. Performance of the induced mutant lines and Basmati 370. Punjab, Pakistan.**

| Mutant, variety | Plant ht (cm) | Duration (d) | Productive tillers (ns./plant) | Yield (g/plant) | Yield (t/ha) |
|---|---|---|---|---|---|
| DM24 | 122.7 | 105 | 15 | 25 | 4.6 |
| DM25 | 125.7 | 106 | 15 | 24 | 4.6 |
| DM28 | 131.3 | 105 | 12 | 22 | 4.2 |
| DM38 | 121.7 | 105 | 14 | 23 | 4.1 |
| Basmati 370 | 160.5 | 104 | 12 | 21 | 4.0 |
| LSD (0.05) | 4.2 | ns | 2 | 1 | 0.1 |

**Table 2. Physicochemical characteristics of rice mutants and Basmati 370. Punjab, Pakistan.**

| Variety, mutant | Length[a] (mm) | Width[a] (mm) | Length-to-width ratio[a] | Quality index[a] | Elongation ratio[a] | Amylose[b] (%) |
|---|---|---|---|---|---|---|
| DM24 | 6.9 | 1.8 | 3.9 | 2.3 | 1.9 | 24 |
| DM25 | 6.7 | 1.7 | 3.9 | 2.4 | 1.9 | 23 |
| DM28 | 6.6 | 1.7 | 3.8 | 2.5 | 1.7 | 23 |
| DM38 | 6.7 | 1.7 | 3.8 | 2.4 | 1.8 | 23 |
| Basmati 370 | 6.9 | 1.8 | 3.8 | 2.3 | 1.8 | 23 |
| LSD (0.05) | 0.15 | ns | ns | 0.10 | ns | ns |

[a]Av of 10 determinations. [b]Av of 3 determinations.

mutants were 18-24% shorter.

Yield samples were milled, polished, and evaluated for their physicochemical characteristics. All mutants had grain quality similar to Basmati 370 (Table 2). □

## Upland rice varieties released in Burundi

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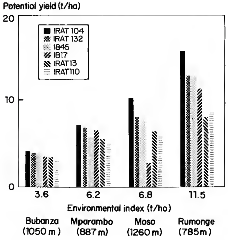
Upland rice has been planted for two centuries by Arabized populations along Lake Tanganyika. The Institut des Sciences Agronomiques du Burundi (ISABU) has decided to develop upland riziculture for 800-1300 m altitude in the Imbo and Kumoso plains.

In 1985, four improved varieties from IRAT and two local populations were evaluated at four stations (Fig. 1). Potential yields were estimated from yields in 30 15-cm pots. Statistical analysis of yields between varieties showed no significant difference at Bubanza (F=2.13), a highly significant difference at Mparambo (F=5.58**), and a very highly significant difference at Moso (F=10.47***) and Rumonge (F=9.29***). Results are very highly significant for varieties (F=19.6***), sites (F=54.6***), and variety × site interaction (GXE-F=5.5***).

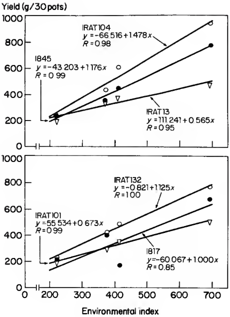
To isolate responsive varieties (b > 1) for intensive riziculture, a regression analysis of yield on environment was made (Fig. 2). Environment was taken to mean such diverse factors as fertility, water supply, climatology, and disease and is the mean of yields at each site.

Three varieties showed a positive interaction: IRAT104 (b=1.47), IRAT132 (b=1.12), IB45 (b=1.17). One, IB17, showed no interaction (b=1); and two, IRAT13 and IRAT101, were stable (b < 1). The stable nature of IRAT13 is attenuated by its susceptibility to *Sarocladium oryzae*, a major pest at middle altitudes (1000-1400 m) in Burundi.

IB45 showed total resistance to *S. oryzae*. All the IRAT varieties are susceptible. □




1. Potential yield of 4 improved and 2 local varieties at 4 stations. Bujumbura, Burundi, 1985. Station altitude is in parentheses.




2. Regression analysis of yield.

## Guarani, a high-yielding short-cycle upland rice for Midwest Brazil

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CNAx 095-BM30-BM9-28, a line selected from the cross IAC25/63-83 has been released as Guarani for Midwest Brazil.

Guarani is a short-duration variety (105-110 d), 100 cm tall. Leaves and spikelets are pubescent and panicles are semicompact, showing good spikelet fertility. Grains are 7.30 mm long and 2.67 mm wide with good cooking quality. In multilocation trials, it was superior to check in blast and drought resistance.

Overall average grain yield (2.7 t/ha) is 15% more than that of the traditionally grown short-duration IAC165 (see table). □

**Average grain yield of Guarani and IAC165 in 4 states of Brazil, 1982-86.**

| State | Trials (no.) | Av yield (t/ha) | | Yield increase (%) |
|---|---|---|---|---|
| | | Guarani | IAC165 | |
| Goiás | 41 | 2.8 | 2.5 | 14 |
| Mato Grosso | 12 | 2.6 | 2.2 | 17 |
| Minas Gerais | 7 | 2.4 | 1.9 | 26 |
| Mato Grosso do Sul | 7 | 2.2 | 2.1 | 6 |
| Av | | 2.7 | 2.3 | 15 |

## RY1 - a newly released upland variety for Zaire

*B. Longanza, M. Baibinge, and U. Alitum, Programme de Recherches sur le Riz, Centre de Recherches de Yangambi, INERA, B.P. 2015, Kisangani, Zaire*

In 1976, seven varieties received from IRAT Cote d'Ivoire, were included in observational trials. RY1, RY2, and RY7 were selected for advanced yield trials 1977-80 in three locations, with R66 (check) and C4-1-5.

RY1 yields in Yangambi, Bambesa, and Boketa were 30% and 23% more than that of local check R66 (Table 1).

RY1 is moderately tall (142 cm), making hand harvesting easier and reducing lodging susceptibility in

Table 1. Performance of 4 varieties in 3 locations in Zaire, 1977-80.

| Location | Mean yield (t/ha) | | | | | % over local check R66 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | R66 | C4-1-5 | RY1 | RY2 | RY7 | C4-1-5 | RY1 | RY2 | RY7 |
| Yangambi | 2.5 | 2.8 | 3.3 | 2.8 | 2.6 | 8 | 30 | 12 | 2 |
| Bambesa | 3.0 | – | 3.9 | 4.0 | 3.4 | – | 30 | 34 | 14 |
| Boketa | 1.8 | – | 2.3 | 2.0 | 2.3 | – | 23 | 10 | 23 |

Table 2. Main characters of 5 varieties at Yangambi, Zaire.

| Characteristic | R66 | C4-1-5 | RY1 (IRAT2) | RY2 (IRAT8) | RY7 (IRAT13) |
|---|---|---|---|---|---|
| Origin | Local | Local | Côte d'Ivoire | Côte d'Ivoire | Côte d'Ivoire |
| *Characteristics* | | | | | |
| Duration (d) | 120 | 115 | 120 | 125 | 130 |
| Plant height (cm) | 166 | 162 | 142 | 141 | 110 |
| Lodging (score) | 5 | 5 | 3 | 3 | 1 |
| *Grain characters* | | | | | |
| Length (mm) | 9.2 | 9.5 | 9.8 | 8.6 | 10.8 |
| Width (mm) | 3.0 | 3.0 | 3.1 | 2.8 | 3.6 |
| Thickness (mm) | 2.0 | 2.1 | 2.1 | 2.0 | 2.0 |
| L/W ratio | 3.1 | 3.2 | 3.2 | 3.0 | 3.0 |
| L/T ratio | 1.5 | 1.4 | 1.4 | 1.4 | 1.8 |
| 1000-grain weight | 32.0 | 34.1 | 37.9 | 24.7 | 39.0 |
| Translucency (%) | 82.0 | 72.0 | 57.3 | 60.9 | 59.8 |
| Leaf blast reaction | Moderately susceptible | Resistant | Resistant | Resistant | Resistant |

locations where strong winds frequently induce severe losses. It is also more resistant to leaf blast. All other characters are good (Table 2).

RY1 was released in Zaire in 1982 to replace R66. □

*The **International Rice Research Newsletter** invites contributions of concise summaries of significant current rice research for publication. Contributions should be limited to no more than 2 pages typed double-spaced, accompanied by no more than 2 figures, tables, or photographs. Contributions are reviewed by appropriate IRRI scientists and those accepted are subject to editing and abridgment to meet space limitations Authors are identified by name and research organization. See inside front cover for more information about submissions.*

# Seed technology

## Modified roll-towel method to determine rice seed vigor

*C. Dharmalingam, Tamil Nadu Agricultural University, Tamil Nadu Rice Research Institute, Aduthurai 612101, India*

The International Seed Testing Association recommends the roll-towel method to test germination of small and medium size seeds. But seedling growth varies considerably with this method. We developed a modified roll-towel (MRT) method that allows unobstructed root growth for a more reliable estimate of seed vigor.

The germination test was made on a 30-cm × 20-cm 600-gauge polythene sheet. Presoaked 2-cm × 20-cm germination paper strips were spread evenly over the top of the polythene sheet. Seeds were placed in a single row, embryo side down, on the germination paper and held in position by covering them with another presoaked germination paper strip, gently pressed down. Germination paper cut to the size of the polythene sheet was spread over all. The polythene sheet with the seeds was rolled lengthwise and secured with rubber bands on either end. The roll was kept slanted inside a medium-size plastic container containing 2-3 cm deep water.

Growth of 10-d-old seedlings and the variability between the 2 test methods are given in the table. Seedling growth improved with little variability.

The MRT method has these advantages:

- Seedlings showed uniform growth;
- Roots grow downward without coiling or curling on the paper;
- Capillary movement of water prevents waterlogging;
- No need to add water during germination unless water in the container dries up;
- Less time-consuming and occupies little space in the germination cabinet;
- Equally good for small and medium size seeds; and
- Cheaper than other methods and materials required are easily available.

Root growth is partially visible from outside and the roll can be unfurled when needed. □

Growth and variability of 10-d-old rice seedlings.[a] Aduthurai, India.

| Growth parameter | Rolled towel | Modified rolled towel |
|---|---|---|
| Germination (%) | 91.2 ± 1.4 | 93.7 ± 1.2 |
| Root length (mm) | 174.6 ± 12.3 | 192.4 ± 2.1 |
| Shoot length (mm) | 103.7 ± 11.7 | 106.6 ± 3.9 |
| Dry mass (mg/10 seedlings) | 116.7 ± 9.9 | 126.6 ± 2.2 |

[a]Mean ± SD of 10 samples.

*The **International Hybrid Rice Newsletter** is published for researchers in hybrid rice development and technology. Its content focuses on discussions of current issues; it does not publish research reports. For more information, write Dr. S. S. Virmani, **Hybrid Rice Newsletter** editor, IRRI, P.O. Box 933, Manila, Philippines.*

# CROP AND RESOURCE MANAGEMENT

## Soil microbiology and biological N fertilizer

### Response of different rice varieties to *Azospirillum* sp. inoculation

*G. Gopalaswamy and P. Vidhyasekaran, Tamil Nadu Rice Research Institute (TRRI), Aduthurai 612101, India*

We raised TKM9, ADT36, IR50, and ADT37 during Jul-Oct 1987. Soil was fertilized with 75 kg N/ha in the form of urea in 3 splits (50%, 25%, 25%), 37.5 kg P/ha in the form of superphosphate (all basal), and 37.5 kg K/ha in the form of muriate of potash (all basal).

Bacterial inoculation was done by soaking 60 kg seeds for 24 h in 60 liters water containing 2 kg peat-based inoculum. Sprouted seeds were sown in the nursery. At 25 d after seeding, seedlings were pulled up and the roots dipped for 20 min in 40 liters water containing 2 kg inoculum. Another 2 kg inoculum was mixed with 15 kg sand and broadcast in the main field before transplanting. Plot size was 15 $m^2$ with 3 replications.

*Azospirillum* sp. inoculation increased number of productive tillers and straw and grain yield of all test varieties (see table). □

**Response of rice varieties to Azospirillum inoculation. TRRI, Aduthurai, India, 1987.**

| Variety | Productive tillers (no./hill) | | | Straw yield (t/ha) | | | Grain yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Without Azospirillum | With Azospirillum | Increase (%) | Without Azospirillum | With Azospirillum | Increase (%) | Without Azospirillum | With Azospirillum | Increase (%) |
| TKM9 | 7.1 ± 0.3 | 8.1 ± 0.7 | 14 | 5.4 ± 1.0 | 6.9 ± 1.3 | 27 | 4.4 ± 0.7 | 5.4 ± 0.9 | 22 |
| ADT36 | 6.0 ± 0.4 | 7.1 ± 0.7 | 18 | 4.7 ± 0.2 | 5.9 ± 0.5 | 26 | 4.0 ± 0.1 | 5.0 ± 0.2 | 26 |
| IR50 | 7.2 ± 0.3 | 8.4 ± 0.3 | 17 | 4.2 ± 0.3 | 5.7 ± 0.7 | 35 | 3.6 ± 0.5 | 5.0 ± 0.4 | 38 |
| ADT37 | 5.3 ± 0.5 | 6.6 ± 0.6 | 24 | 4.6 ± 0.3 | 5.8 ± 0.2 | 27 | 3.9 ± 0.2 | 4.8 ± 0.2 | 24 |

### Green manure crop performance in semiarid region of India

*S. K. Sharma and K. K. Murthy, Agronomy Department, Directorate of Rice Research, Rajendranagar, Hyderabad 500030, Andhra Pradesh, India*

A field trial during 1986-1987 wet and dry seasons examined the performance of *Sesbania rostrata, S. aculeata, S. speciosa,* and *Crotalaria juncea* L.

The 1986 wet season crop was sown 13 May at 30- × 10-cm spacing in 8- × 2-m plots. This experiment was a single unreplicated plot. The 1986-87 dry season crop was broadcast on 12 Dec in 25- × 4-m plots. The 1987 wet season crop was sown on 6 Jun at 30-cm spacing for *Sesbania* species and 20-cm spacing for *C. juncea* in 25- × 5-m plots. The Dec and Jun experiments were laid out in a randomized block design with three replications. Fertilizer was 20 kg N and 17.6 kg P/ha, incorporated before sowing. One irrigation was given at sowing for germination.

Plant stands were uniform in all plots. Growth was recorded on 10 plants collected at random at 48 d after sowing

**Table 1. Plant height and fresh weight of green manure crops sown in May 1986 in Hyderabad, India.**

| Green manure crop | Plant height (cm) | Fresh weight (g) |
|---|---|---|
| *S. aculeata* | 151.5 | 172.0 |
| *S. rostrata* | 158.0 | 158.0 |
| *S. speciosa* | 77.6 | 69.6 |

**Table 2. Plant height and fresh and dry weight of green manure crops grown in dry (Dec) and wet (Jun) seasons. Hyderabad, India, 1986-87.**

| Green manure | Plant height (cm) | | | Fresh weight (g) | | | Dry weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Dry season 1986 | Wet season 1987 | Mean | Dry season 1986 | Wet season 1987 | Mean | Dry season 1986 | Wet season 1987 | Mean |
| *S. aculeata* | 38.3 | 148.0 | 93.2 | 10.7 | 57.3 | 34.0 | 2.7 | 14.0 | 9.4 |
| *S. rostrata* | 25.3 | 139.0 | 82.2 | 9.4 | 58.0 | 33.7 | 2.4 | 13.7 | 9.0 |
| *C. juncea* L. | 29.0 | 84.0 | 56.5 | 6.0 | 24.3 | 15.2 | 1.7 | 6.0 | 3.8 |
| Mean | 30.9 | 123.7 | | 8.7 | 46.6 | | 2.3 | 11.2 | |
| LSD (0.05) | | | | | | | | | |
| Season | 9.7 | | | 5.0 | | | 0.8 | | |
| Green manure | 11.9 | | | 6.1 | | | 1.0 | | |
| Season × green manure | 16.8 | | | 8.7 | | | 1.4 | | |
| CV (%) | 12.0 | | | 17.2 | | | 11.8 | | |

(DAS) for May and Dec sown crops and at 57 DAS for the Jun crop.

*S. aculeata* and *S. rostrum* had similar performance irrespective of date of sowing (Table 1, 2). The May-sown crop performed best (May is the most appropriate time for growing a green manure crop to fit local rice-based cropping systems). The Jun-sown crop had reduced plant height and less biomass production. The Dec crops had very poor growth. □

## Biofertilizer efficiency in lowland rice

*S. Jeyaraman and S. Purushothaman, Agricultural College and Research Institute. Tamil Nadu Agricultural University, Madurai 625104, India*

We studied the efficiency of blue-green algae, Azospirillum, and azolla alone and with 50, 75, and 100 kg N/ha during wet and dry seasons 1986-87. Treatments were in a randomized block design with three replications.

*Azospirillum lipoferum* at $10^8$ cells/g inoculant was inoculated at 1 kg/ha by seedling root dip for 20 min. A composite culture of blue-green algae was applied in the soil at 10 kg/ha 10 d after transplanting (DT). *Azolla pinnata* was established as dual crop at 1 t/ha 10 DT and the azolla mat incorporated at 20 d and 40 d.

**Effect of biofertilizers on grain yield. Madurai, India, 1986-87.**

| Treatment | Grain yield (t/ha) | |
|---|---|---|
| | Kharif (CO 37) | Rabi (IR20) |
| 100 kg N/ha alone | 5.9 | 4.2 |
| 75 kg N/ha alone | 5.7 | 6.0 |
| 50 kg N/ha alone | 5.0 | 3.8 |
| 75 kg N/ha + blue-green algae | 6.2 | 4.5 |
| 75 kg N/ha + azolla | 5.9 | 4.5 |
| 75 kg N/ha + Azospirillum | 6.4 | 4.5 |
| 50 kg N/ha + blue-green algae | 5.6 | 4.0 |
| 50 kg N/ha + azolla | 5.2 | 4.1 |
| 50 kg N/ha + Azospirillum | 5.9 | 4.0 |
| Blue-green algae alone | 4.8 | 3.2 |
| Azolla alone | 4.6 | 3.3 |
| Azospirillum alone | 4.9 | 3.3 |
| No fertilizer control | 4.1 | 2.8 |
| LSD (0.05) | 0.5 | 0.3 |

Azospirillum with 75 kg N/ ha influenced grain yield the most, with a significant increase in wet season rice and a dry season yield comparable to that with 100 kg N/ha (see table). In both seasons, yields with blue-green algae and 75 kg N/ ha or dual cropping of azolla, and that with Azospirillum with 50 kg N/ ha were comparable with yield with 100 kg N/ha. □

## Effect of Azospirillum biofertilizer on rice yield

*S. Rajagopalan and M. Rangaswamy, Rice Research Station, Ambasamudram 627401, Tamil Nadu, India*

We compared the effect of Azospirillum biofertilizer with that of organic manure at various levels of N during kharif (Jun-Sep) and rabi (Oct-Feb) 1986-87. Test varieties were IR50 in kharif and IR20 in rabi. The experiment was laid out in a split-plot design with three replications.

Soil was a sandy loam with pH 6.8, EC 0.43 dS/m, and 297-40-153 kg available NPK/ha. Farmyard manure

**Table 1. Productive tillers and grain yield with organic manure and Azospirillum application at 4 N levels.[a] Tamil Nadu, India, 1986 kharif.**

| Treatment | Productive tillers (no./m$^2$) | | | | | Grain yield (t/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No N | 49 kg N/ha | 73 kg N/ha | 98 kg N/ha | Mean | No N | 49 kg N/ha | 73 kg N/ha | 98 kg N/ha | Mean |
| Control | 487 | 531 | 549 | 566 | 533 | 3.2 | 3.8 | 3.9 | 4.1 | 3.8 |
| 5 t FYM/ha | 501 | 544 | 556 | 572 | 543 | 3.3 | 3.7 | 4.0 | 4.4 | 3.9 |
| Azospirillum (nursery + main field) | 535 | 550 | 556 | 564 | 551 | 3.3 | 3.9 | 4.1 | 4.2 | 3.8 |
| FYM + Azospirillum | 489 | 521 | 550 | 576 | 534 | 3.2 | 3.8 | 4.1 | 4.5 | 3.9 |
| Mean | 503 | 536 | 553 | 569 | | 3.3 | 3.8 | 4.0 | 4.3 | |

| | LSD | LSD |
|---|---|---|
| FYM × Azospirillum | ns | ns |
| Levels of N | 25 | 0.2 |
| FYM × Azospirillum × N level | ns | ns |

[a]N applied per soil test recommendation, with 98 kg N/ha = 100% N.

**Table 2. Productive tillers and grain yield as influenced by organic manure and Azospirillum at 4 N levels.[a] Tamil Nadu, 1986 rabi.**

| Treatment | Productive tillers (no./m$^2$) | | | | | Grain yield (t/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No N | 49 kg N/ha | 73 kg N/ha | 98 kg N/ha | Mean | No N | 49 kg N/ha | 73 kg N/ha | 98 kg N/ha | Mean |
| Control | 334 | 357 | 378 | 406 | 369 | 2.9 | 3.6 | 3.9 | 4.1 | 3.6 |
| 5 t FYM/ha | 335 | 367 | 373 | 385 | 365 | 2.7 | 3.7 | 4.1 | 3.9 | 3.6 |
| Azospirillum (seed + nursery + root dip + main field) | 351 | 370 | 364 | 453 | 385 | 3.1 | 4.0 | 4.0 | 4.4 | 3.9 |
| FYM + Azospirillum | 380 | 367 | 392 | 454 | 398 | 3.0 | 3.8 | 4.0 | 4.6 | 3.9 |
| Mean | 350 | 365 | 377 | 425 | | 2.9 | 3.8 | 4.0 | 4.3 | |

| | LSD | LSD |
|---|---|---|
| FYM × Azospirillum | 21 | ns |
| Levels of N | 16 | 0.1 |
| FYM × Azospirillum × N level | 32 | 0.3 |

[a]N applied per soil test recommendation, with 98 kg N/ha = 100% N.

(FYM) was applied at 5 t dry weight/ ha in the main field. It contained 0.56% N, 0.13% P, and 0.75% K.

Azospirillum was applied at 2 kg/800 $m^2$ to the nursery area and 2 kg/ha to the main field during 1986 kharif (total 4 kg). In 1986 rabi, Azospirillum was applied 1 kg to seeds needed for 1 ha, 1 kg/ 800 $m^2$ to the nursery, 2 kg/800 $m^2$ as seedling root dip, and 2 kg/ ha to the main field (total 6 kg). Soil application to both nursery and main field was done by mixing 2 kg peat-based inoculant with 25 kg powdered FYM and 25 kg soil. This was uniformly broadcast in the nursery at sowing and in the main field at transplanting. P and K were applied per soil test recommendation to all treatments. For all 4 treatment levels, N was applied as 59% basal and 50% in 2 equal splits at active tillering and panicle initiation.

During kharif, the main effect of biofertilizer and organic manure was not significant individually or in combination, but levels of N in the subplots were significant. Application of 98 kg N/ ha gave significantly higher grain yield than other treatments and 30% higher than control (Table 1). Productive tillers/$m^2$ was also significant for N level.

During rabi, the interaction of N level, organic manure, and biofertilizer application was significant for productive tillers and for grain yield. Combined application of organic manure, Azospirillum, and 100% recommended N resulted in significantly higher yield, on par with 100% N with Azospirillum (Table 2). The more pronounced effect of Azospirillum during rabi than during kharif may be due to its combined application to seed, soil, and roots. □

## Screening azolla strains for shading tolerance

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In dual culture with rice, azolla growth is limited by light deficiency due to rice canopy shading. Beginning 30-40 d after transplanting, the rice crop severely suppresses azolla growth. With azolla strains tolerant of shading, biomass production could be improved and growth prolonged.

We screened 12 azolla strains for shading tolerance in a pot experiment. Azolla was inoculated at 1.4 g fresh weight/ pot (197 g fresh weight/ $m^2$) in 10-cm-diameter beakers and grown on soil-water culture. Triplephosphate was applied weekly. Light intensities of 50% and 15% were attained by shading beakers with green nylon screens (control was left unshaded), with 3 replications. Biomass of azolla was determined every 5 d for 5 wk, and days to biomass doubling computed for the period from inoculation to maximum biomass. Azolla N content at the end of the experiment was determined by micro-Kjeldahl method.

Tested azolla strains did not differ much in tolerance for shading (see table). Strains with the best growth without shading (*A. caroliniana* #310, #311; *A. mexicana* #202; *A. microphylla* #401) also were the best strains with shading. Some strains were particularly well adapted or poorly adapted to shading. *A. microphylla* #417 and *A. caroliniana* #301 were less affected by shading; *A. pinnata* var. *pin.* #49 and #58 were much more affected. *A. filiculoides* #107 obviously was not adapted to tropical conditions and did not grow well.

The N content of the two strains that performed best (*A. caroliniana* #301, *A. mexicana* #202) was increased by shading. □

**Effects of light intensity (100%, 50%, 15%) on growth and N content of 12 azolla strains. Pot experiment, IRRI, 1985.**

| Azolla strain | Accession no. | Maximum biomass[a] (g fresh wt/pot) | | | Doubling time (d) | | | N content (% N in dry wt) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 50 | 15 | 100 | 50 | 15 | 100 | 50 | 15 |
| *A. pinnata var. imbricata* | 5 | 10.07 def | 8.53 cd | 6.05 b | 7.78 | 10.82 | 13.26 | 3.69 | 3.29 | 3.34 |
| *A. pinnata var. imbricata* | 49 | 11.66 bcd | 8.01 de | 4.71 cd | 9.18 | 8.80 | 16.37 | 3.33 | 3.20 | 3.33 |
| *A. pinnata var. imbricata* | 58 | 9.21 efg | 6.69 ef | 3.62 d | 8.33 | 9.87 | 20.37 | 3.52 | 3.37 | 3.81 |
| *A. filiculoides* | 107 | 7.38 gh | 5.10 f | 1.58 e | 14.98 | 14.95 | 28.12 | 4.32 | 4.61 | [b] |
| *A. mexicana* | 202 | 12.18 bc | 13.29 a | 7.89 a | 8.99 | 8.63 | 11.27 | 4.01 | 4.17 | 4.55 |
| *A. caroliniana* | 301 | 6.76 h | 7.94 de | 4.17 cd | 9.89 | 11.23 | 19.33 | 3.49 | 3.57 | 3.47 |
| *A. caroliniana* | 310 | 15.08 a | 14.44 a | 8.35 a | 8.20 | 8.38 | 10.91 | 3.99 | 4.16 | 4.64 |
| *A. caroliniana* | 311 | 13.28 ab | 13.30 a | 7.59 a | 8.63 | 8.64 | 11.83 | 4.30 | 4.01 | 4.04 |
| *A. microphylla* | 401 | 11.76 bcd | 10.80 b | 7.57 a | 7.37 | 9.58 | 9.08 | 4.94 | 4.89 | 4.91 |
| *A. microphylla* | 417 | 8.18 fgh | 9.96 bc | 5.43 bc | 8.71 | 9.91 | 14.46 | 4.45 | 4.51 | 4.26 |
| *A. microphylla* | 418 | 11.15 cde | 9.36 bcd | 5.38 bc | 7.40 | 8.06 | 11.82 | 4.60 | 4.35 | 4.47 |
| *A. pinnata var. pinnata* | 701 | 9.53 ef | 8.58 cd | 5.00 bc | 8.11 | 10.74 | 12.20 | 3.91 | 3.24 | 3.51 |
| LSD (0.05) | | 1.94 | 1.71 | 1.33 | | | | | | |

[a]In a column, means followed by a common letter are not significantly ent by DMRT at the 5% level. [b]Not enough material for analysis.

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# Physiology and plant nutrition

## Effect of nitrogen and zinc on indole-3-acetic acid (IAA) concentration in roots and root production in wetland rice

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IAA triggers meristematic activity and plant growth. A high IAA concentration in rice roots, especially at panicle initiation stage is indicative of high root production and activity and better crop performance.

We measured IAA concentration in rice roots at panicle initiation in relation to N and Zn nutrition at TNAU (11°N, 77°E and 427 m above sea level) during the southwest monsoon season (Jun-Sep) 1983. The factorial design combined 4 levels of N (0, 60, 90, and 120 kg N/ha) and 2 levels of Zn (0 and 5.75 kg/ha). The soil contained 1.1% organic C, 196-9.5-200 ppm available NPK, 598 ppm total soil N, and 0.4 ppm DTPA extractable Zn. Test variety was IR20. The test field was laid out in a randomized block design with six replications.

N and Zn showed a synergistic interaction on IAA concentration in rice roots. At 120 kg N/ha with Zn, IAA in roots was highest (462 µg/kg fresh root); at 120 kg N/ha without Zn, it was very low (281 µg/kg fresh root) (Table 1). IAA concentration was more or less the same at all levels of N without Zn.

**Table 1. N-Zn interactions on rice root IAA content at panicle initiation.[a] TNAU, India, 1983.**

| Zn level | IAA content (µg/kg fresh root) | | | | |
|---|---|---|---|---|---|
| (kg/ha) | No N | N60 | N90 | N120 | Mean |
| 0 | 279 | 283 | 299 | 281 | 278 |
| 5.75 | 348 | 375 | 361 | 462 | 387 |
| Mean | 314 | 329 | 330 | 372 | |

| | *LSD (0.05)* |
|---|---|
| N | 15 |
| Zn | 17 |
| N × Zn | 35 |

[a]N in kg/ha.

Root weight increased with N increase up to 120 kg/ ha at all growth stages (Table 2). Zn also increased root production at all stages. The coefficients of correlation of IAA concentration in rice roots with root dry weight at panicle initiation (0.55), root dry weight at flowering (0.51), and root dry weight at harvest (0.56) were significant and positive. □

**Table 2. Root dry weight at different growth stages as influenced by levels of N and Zn.**

| | Root dry weight (t/ha) | | | |
|---|---|---|---|---|
| | Tillering | Panicle initiation | Flowering | Harvest |
| N level (kg/ha) | | | | |
| 0 | 0.4 | 0.8 | 0.9 | 1.1 |
| 60 | 0.5 | 0.9 | 1.1 | 1.2 |
| 90 | 0.5 | 1.2 | 1.3 | 1.4 |
| 120 | 0.7 | 1.4 | 1.6 | 1.7 |
| LSD (0.05) | 0.05 | 0.1 | 0.1 | 0.1 |
| Zn level (kg/ha) | | | | |
| 0 | 0.5 | 1.0 | 1.1 | 1.3 |
| 5.75 | 0.6 | 1.2 | 1.3 | 1.4 |
| LSD (0.05) | 0.04 | 0.09 | 0.08 | 0.06 |

# Soil fertility and fertilizer management

## Tissue test of rice plant nitrogen

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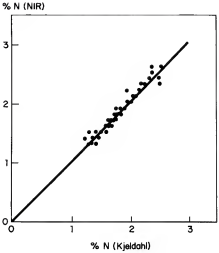
In Australia, rice farmers dry-seed rice by drill sowing directly into a dry seedbed or by drilling into a closely grazed pasture. The crop is flooded 2-4 times before it reaches the 3- to 4-leaf stage, when a permanent flood is applied. Or, fields are permanently flooded with shallow water and pregerminated rice seed is dropped by airplane.

The recommended times for N fertilizer application are just before permanent flood and just after panicle initiation. If farmers are confident of the appropriate fertilizer rate, all or most is applied before the permanent flood. If farmers are unsure of the appropriate fertilizer rates or if there is a risk of overfertilization or low-temperature sterility, one-half to two-thirds N is applied before permanent flood, the remainder at panicle initiation.

A critical management decision is the amount of N to apply at panicle initiation to achieve maximum yield.

We have developed a plant analysis test that can rapidly determine crop N status and estimate N topdressing needed. Whole shoot samples are cut at ground level at panicle initiation, quickly dried in a 700 W microwave oven (200 g fresh wt in 13-15 min), ground in a Cyclone mill to pass through a 1-mm screen, and analyzed for tissue N status by near infrared reflectance (NIR).

NIR gave an excellent correlation with traditional Kjeldahl N analysis (see figure). Preliminary results indicate that




Relationship between NIR and the Kjeldahl methods of measuring rice shoot N status.

yield can be increased by topdressing N when plant N is below 1.5% at panicle initiation.

A 2- to 3-d analysis service is planned. Farmers will collect samples of their crops, dry them in domestic microwave ovens, and send the dry samples to a central laboratory. The laboratory will complete the analysis and advise the farmer on the amount of N fertilizer needed. □

## Effect of source and rate of phosphorus on yield and yield attributes of rice

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A field experiment was conducted during the wet season at the Crop Research Centre (29°N 79.3°E and 243.84 m altitude). The experimental field soil was Beni silty clay loam, fine-silty, mixed, hyperthermic, Aquic Hapludoll with pH 7.6, CEC 20 meq, 1.06% organic C, 20 kg available (Olsen) P/ ha, and 196 kg available K/ ha.

Five P sources—rock phosphate, single superphosphate, rock phosphate + superphosphate, rock phosphate + single superphosphate + pyrite, and rock phosphate + pyrite—at 3 rates—13, 26, and 40 kg P/ha—in 16 combinations were compared. Mussoorie rock phosphate : pyrite and single superphosphate : Mussoorie rock phosphate were mixed in 1:3 ratio. Mussoorie rock phosphate (100 mesh) was applied on the basis of 7% total P (2% citrate soluble). Pyrite was mixed and applied 15 d before transplanting in dry soil.

Rice variety Pant Dhan 4 seedlings were transplanted at 20- × 20-cm spacing at 2-3 seedlings/ hill. The crop was fertilized with 120 kg N and 9 kg Zn/ha. No K was applied.

Grain yield, panicles/m$^2$, and filled grains/panicle with single superphosphate were significantly higher than with all other sources of P (see table). Other sources were also significantly superior to rock phosphate alone in effect on yield and yield attributes. Percentage unfilled grains decreased significantly with single superphosphate but was significantly higher with rock phosphate than with any other source.

P significantly increased grain yield, panicles/m$^2$, and filled grains/panicle. □

**Grain yield and yield attributes of rice as influenced by source and rate of** *P. Nainital,* **India.**

| Treatment | Grain yield (t/ha) | Panicles/m$^2$ | Filled grains/panicle | 1000 grain wt (g) | Unfilled grain (%) |
|---|---|---|---|---|---|
| *Source* | | | | | |
| Rock phosphate | 4.4 | 205 | 104 | 25.4 | 18.4 |
| Superphosphate | 5.4 | 252 | 108 | 25.7 | 13.1 |
| Rock phosphate + superphosphate | 4.7 | 219 | 107 | 25.8 | 15.7 |
| Rock phosphate + superphosphate + pyrite | 4.8 | 227 | 108 | 25.6 | 14.3 |
| Rock phosphate + pyrite | 4.7 | 220 | 108 | 25.8 | 15.2 |
| LSD (P = 0.05) | 0.2 | 7 | 2 | ns | 0.6 |
| *Rate (kg P/ha)* | | | | | |
| 13 | 4.6 | 215 | 106 | 25.5 | 17.1 |
| 26 | 4.8 | 228 | 107 | 25.8 | 14.9 |
| 40 | 4.9 | 231 | 108 | 25.7 | 14.0 |
| LSD (P = 0.05) | 0.2 | 5 | 2 | ns | 0.5 |
| Control | 4.3 | 193 | 100 | 25.6 | 20.4 |
| Mean | 4.77 | 223 | 107 | 25.6 | 15.6 |

## Effect of modified urea on rice yield

*S. V. Subbaiah and S. K. Sharma, Agronomy Department, Directorate of Rice Research, Rajendranagar, Hyderabad 500030, Andhra Pradesh, India*

We studied the effect of an experimental coating material on N fertilizer use efficiency under lowland conditions during 1987 wet season. The coating material is a nonhydrous free-flowing liquid with a mild characteristic odor. The active principles that exert a nitrification regulatory effect are terpenoids and flavonoids compounded with certain polysaccharides and aldehydes.

The soil is a Vertisol with pH 8.4, CEC 50 meq/ 100 g soil, 0.1% total N (modified Kjeldahl method), and 6 ppm available P (Olsen's method). The experimental field was fertilized with 17.5 kg P and 33 kg K/ha at final puddling and 58 kg N/ha per treatment.

N fertilizers used were prilled urea (PU), large granule urea (LGU), and urea supergranule (USG). One percent of the experimental material and 5% neem cake powder were used to coat the modified urea materials.

Coated PU, LGU, and USG (hand placed 7 d after transplanting [DT]) with or without the new coating increased grain yield significantly over PU applied as standard split (2/3 basal, 1/3 at panicle initiation) (see table).

**Yield of rice Rasi as influenced by coated urea materials. Andhra Pradesh, India, 1987 wet season.**

| Treatment | Grain yield (t/ha) |
|---|---|
| Control | 3.5 |
| PU (standard split) | 4.1 |
| PU + new coating (basal) | 4.8 |
| LGU (basal) | 5.3 |
| LGU (standard split) | 4.7 |
| LGU + new coating (basal) | 5.0 |
| LGU + new coating (split) | 5.1 |
| USG placement, 7 DT | 5.6 |
| Neem cake-coated USG (7 DT) | 5.9 |
| New coating + USG (7 DT) | 5.6 |
| Experimental mean | 5.0 |
| LSD (0.05) | 0.4 |
| CV (%) | 5.1 |

There was no significant grain yield difference among USG, neem cake-coated USG, and USG with the new coating. ☐

## Effect of urea-based N sources in rice - wheat cropping sequence

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We compared 5 urea sources—prilled urea (PU), gypsum-coated urea (GCU), nitrohumic-coated urea (NHCU), urea supergranule (USG), and Mussoorie phos-coated urea (MPCU) — at 56, 84, and 112 kg N/ha in a 1986-87 wet season-winter season field experiment.

Soil was a clay loam with pH 7.3, 0.34% organic C, 9.7 kg available P/ha ($NaHCO_3$ extract), and 132.8 kg available K/ha (ammonium acetate extract). The experiment was in a split-plot design (N in the main plots and sources in the subplots) with three replications.

Seedlings of 150-d-duration rice variety Jaishree at 2/hill were transplanted on 19 Jul at 20- × 15-cm spacing. All plots received 17.2 kg P and 16.6 kg K/ha. All GCU (31% N), NHCU (46% N), USG (46% N), MPCU (32% N), and 1/3 PU were applied at transplanting. USG was placed 8 cm deep in the center of 4 hills 10 d after transplanting (DT). Additional PU was applied in equal splits at 20 DT and at panicle initiation. The other N sources were incorporated at puddling.

The rice crop was harvested 20 Nov and the succeeding wheat crop, cultivar HP 1209, was sown 12 Dec. The wheat crop was fertilized with 50 kg N, 21.5 kg P, and 20.7 kg K/ha including the previous control plots. The wheat crop received three irrigations.

Rice grain yield increased significantly up to 112 kg N/ha because of increased panicles/m$^2$ and filled spikelets/panicle (see table). Yields with USG were similar to those with PU and significantly greater than those with other N sources. The higher yield with USG was due mainly to larger panicles/m$^2$ and filled spikelets/panicle.

Residual effects of 84 and 112 kg N/ha were similar and significantly superior to those of 56 kg N/ha in the succeeding wheat crop (see table). Maximum wheat grain yield in the plot that received USG for the preceding rice was significantly superior to that with PU alone. ☐

**Rice yield attributes, rice grain yield, and wheat grain yield with urea-based N sources. Bihar, India, 1986-87 wet-winter seasons.**

| Treatment | Panicles (no./m$^2$) | Filled spikelets/ panicle | 1000-grain wt (g) | Grain yield (t/ha) | |
|---|---|---|---|---|---|
| | | | | Rice | Wheat |
| N (kg/ha) | | | | | |
| 0 | 169 | 70.1 | 19.8 | 2.3 | 2.5 |
| 56 | 229 | 90.5 | 21.3 | 3.1 | 2.9 |
| 84 | 243 | 98.0 | 22.1 | 3.5 | 3.0 |
| 112 | 263 | 99.9 | 22.5 | 3.8 | 3.2 |
| LSD (0.05) | 7.6 | 2.3 | 0.2 | 0.1 | 0.2 |
| Forms of urea | | | | | |
| PU | 250 | 92.8 | 22.1 | 3.6 | 2.9 |
| GCU | 232 | 96.8 | 21.8 | 3.3 | 3.0 |
| NHCU | 241 | 95.6 | 21.9 | 3.5 | 3.0 |
| USG | 261 | 100.6 | 21.2 | 3.8 | 3.2 |
| MPCU | 244 | 94.8 | 22.0 | 3.2 | 3.1 |
| LSD (0.05) | 6.9 | 2.4 | ns | 0.2 | 0.2 |

## Effect of N source and application method on dry season irrigated rice

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We studied timing of urea application and method of urea supergranules (USG) placement on a clay loam soil with pH 6.5, 0.07% total N, 20 ppm available P, and 0.2 meq exchangeable K/100 g soil. Treatments are given in the table.

N was applied at 58 kg/ha. Urea was

**Effect of N source and method of application on performance of BR3 at BRRI.[a] Bangladesh.**

| Treatment[b] | Panicles (no./m$^2$) | Grain yield (t/ha) | N efficiency (kg grain/kg N) | N recovery (%) |
|---|---|---|---|---|
| No N | 202 f | 3.31 d | – | – |
| Urea 1/2 basal + 1/2 MT | 222 e | 4.31 c | 17.25 | 20.6 |
| Urea 1/3 basal + 1/3 IT + 1/3 5-7 DBPI | 244 d | 4.54 c | 21.14 | 25.9 |
| Urea 1/3 IT + 1/3 RT + 1/3 5-7 DBPI | 252 c | 4.63 c | 22.67 | 31.0 |
| USG deep placed with open hole | 298 b | 5.31 ab | 34.34 | 58.6 |
| USG deep placed with closed hole | 305 a | 5.49 a | 37.56 | 67.2 |
| CV (%) | 7.4 | 4.4 | | |

[a]In a column, means followed by a common letter are not significantly different at the 5% level of DMRT. [b]Except for no N, N for all treatments is 58 kg/ha. MT = maximum tillering, IT = initial tillering, RT = rapid tillering, DBPI = days before panicle initiation.

incorporated after application except at panicle initiation. USG was applied after seedling establishment at 10-12 cm soil depth. All treatments received 20-30-20 kg PKS/ha. Test variety was BR3.

Application of N as prilled urea (PU) or as USG significantly improved panicle number/m$^2$ and grain yield over no N (see table). Deep point placement of USG resulted in significantly higher grain yield than split application of PU.

Further increase in grain yield, better N use efficiency (kg grain/kg N), and higher apparent N recovery occurred when the hole was closed after USG application. □

# Disease management

## Occurrence of rice sheath blight (ShB) *Rhizoctonia solani* Kuhn on rice panicles in India

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Rice ShB (*Rhizoctonia solani* Kuhn) normally attacks the leaf sheath and leaf blade. We found characteristic symptoms of the disease at the time of panicle emergence. Affected panicles were a chaffy, greyish brown, cylindrical rod matted together by the mycelium of the fungus (see figure). Many white and mustard seed-like, brown sclerotia that formed on the diseased panicle were easily detached. The fungus easily infected rachis and its branches but could not affect the panicle neck.

Sclerotia from the infected panicles were collected and isolated on potato dextrose agar. Mycelium is white, and septate. Its internodal area range was 20 × 120-40 × 350 µm. Sclerotia are more or less globose, white when young, then becoming dark brown. Individual sclerotium measured up to 4 mm, but could clump in culture to form a larger sclerotia.

Spraying mycelium fragments prepared from 5-d-old culture on just emerged panicles, leaves, and leaf sheaths of susceptible rice variety IR50 induced disease symptoms similar to those of rice ShB. Spraying IR50 plants with sterile water did not induce disease. □

Rice panicles infected with *Rhizoctonia solani* Kuhn in India.

## Device for field measurement of conidia release by a single leaf blast lesion

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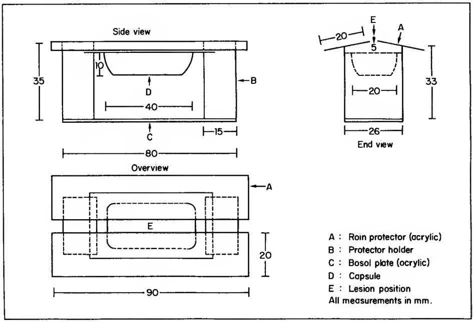
In the study of the life cycle of rice blast fungus *Pyricularia oryzae*, measurement under field conditions of the conidia released from a single lesion is important in understanding conidia dispersal pattern. Some preliminary experiments to improve spore catch efficiency were done during the 1985 crop season in Korea. Using those results, we devised a new KY type spore trap (see figure).




The KY type spore trap. Korea, 1985

A discrete lesion-bearing leaf is fixed with double-sided adhesive tape on the acrylic rain protector without detaching the leaf from the plant. A basin-shaped acrylic capsule 40 mm long is placed just beneath the lesion. Collection is at 1- or 24-h intervals. Spores can be counted immediately or the capsule can be sealed with masking tape and the spores counted a few weeks or months later. When spores are counted 0.1 ml of 0.02% Tween 20 solution are added to the capsule and the conidia counted with a hemacytometer. Spores in one capsule can be counted in less than 10 min.

The table shows the number of conidia released from a single lesion in Jul 1987. The amount varies, depending upon the condition of the lesion as well as on the weather. The maximum number exceeded 30,000 conidia/d, suggesting the usefulness of a KY type spore trap to study conidia release under natural conditions. □

*P. oryzae* **conidia released from discrete blast lesions[a] of rice cultivars Jinheung and Jinju. Korea, 1987.**

| Date surveyed | Conidia (no.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jinheung | | | | | Jinju | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 3 Jul | 40 | 80 | 500 | 220 | 40 | 160 | 140 | 460 | 80 | 160 |
| 4 Jul | 280 | 460 | 320 | 420 | 60 | 600 | 220 | 980 | 200 | 520 |
| 5 Jul | 140 | 180 | 680 | 80 | 340 | 700 | 300 | 720 | 120 | 140 |
| 6 Jul | 100 | 460 | 320 | 100 | 120 | 720 | 0 | 280 | 300 | 960 |
| 7 Jul | 100 | 380 | 920 | 320 | 540 | 700 | 280 | 740 | 280 | 220 |
| 8 Jul | 120 | 5,360 | 10,620 | 2,620 | 5,660 | 15,800 | 7,060 | 13,720 | 8,860 | 5,420 |
| 9 Jul | 300 | 2,720 | 5,900 | 940 | 3,480 | 12,600 | 2,680 | 30,560 | 4,240 | 10,720 |
| 10 Jul | 2,960 | – | 3,000 | 880 | 1,200 | – | 820 | 1,240 | 1,500 | – |

[a]Lesions appeared 2 Jul.

## Screening antibiotics for their control of bacterial blight (BB)

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No effective control against rice BB has been reported so far. A few antibiotics, such as streptomycin and oxytetracycline, have been tried with little success. We evaluated several new combinations of antibiotics and commonly available antibiotics for their efficacy in disease control.

Rice variety ADT38 was grown in the field Aug-Nov 1987. At maximum tillering, plants were sprayed with 1,000 ppm concentrations of different antibiotics, with 3 replications. After 24 h, leaves were clip-inoculated with 72-h-old *Xanthomonas campestris* pv. *oryzae* culture ($10^8$ cfu/ml). Disease intensity and leaf area affected were assessed 16 d after inoculation.

Of the antibiotics tested, only chloramphenicol effectively controlled BB (see table). In chloramphenicol treated leaves, only 11% of the leaf area was affected; in unsprayed leaves, 60% of the leaf area was affected. □

**Effect of antibiotics on control of BB of rice. Aduthurai, India, Aug 1987.**

| Antibiotic[a] | Disease intensity[b] | |
|---|---|---|
| | Grade[c] | Leaf area affected (%) |
| Chloramphenicol | 3.6 a | 11.0 a |
| Streptomycin | 5.6 b | 32.2 b |
| Oxytetracycline | 6.4 bcd | 41.8 bcd |
| Streptocycline | 6.3 bcd | 40.6 bcd |
| Streptomycin + penicillin | 5.7 bc | 33.4 bc |
| Erythrocin | 5.6 b | 32.2 b |
| Ampicillin | 5.7 bc | 33.4 bc |
| Cloxacillin | 6.4 bcd | 41.8 bcd |
| Amoxycillin | 6.6 cd | 44.2 cd |
| Cephexlin | 6.9 cde | 47.8 cd |
| Ampicillin + cloxacillin | 7.3 de | 57.5 de |
| Amoxycillin + cloxacillin | 6.3 bcd | 40.6 bcd |
| Trimethoprim + sulphamethoxazole | 6.4 bcd | 41.8 bcd |
| Control | 7.4 e | 60.0 e |

[a]Combinations of antibiotics are manufacturer formulations. [b]In a column, means followed by the same letter do not differ significantly at P = 0.05 by DMRT. [c]By the *Standard evaluation system for rice* scale.

## Occurrence of bacterial leaf streak (BLS) in Nigeria

*R. C. Chaudhary, Federal Agricultural Coordinating Unit, P. M. B. 2277, Kaduna; and V. T. John, International Institute of Tropical Agriculture, Ibadan, Nigeria*

During a survey, symptoms of BLS were noticed on rice variety Gwangulu (ex-China), popularly grown in the irrigated fields of Gafan 2 in Kadawa, Northern Nigeria. Later, BG90-2, also a lowland variety, showed symptoms. In both varieties, symptoms consisted of narrow, linear, yellowish lesions with the bacterial ooze droplets characteristic of BLS.

The disease was identified as caused by *X. c.* pv. *oryzicola* by appropriate laboratory tests. No authenticated record of this disease in Nigeria had existed.

Similar symptoms were seen on IR46 in Garoua fields of northern Cameroon (SEMRY) during a 1985 survey. In both Nigeria and Cameroon, disease incidence was of low intensity and did not affect the crop. □

*For instructions on preparation of brief reports of rice research to submit for publication in IRRN, see the inside front cover of this issue.*

# Insect management

## Pest abundance in sequentially planted crops

*H. D. Justo, Jr., B. M. Shepard, V. A. Perez, E. Tiongco, H. Hibino, Entomology Department and Plant Pathology Department, IRRI and T. Tsuboi, Bohol APC-JICA, Philippines*

We studied the impact of time of crop establishment on relative abundance of pests in Sierra Bullones, Bohol, Philippines Aug 1987-Jan 1988. Three neighboring 0.6-ha fields were planted at monthly intervals with tungro (RTV)-susceptible IR64, first planting in Aug (normal planting), the second in Sep, the third in Oct.

Green leafhopper (GLH) populations were monitored by weekly sweep net sampling from seedling stage to about 60 days after transplanting (DT). The pest population showed a gradual but steady increase, with a peak during maximum tillering. A significantly higher GLH population density was recorded on the third planting (see table). Peak catches of GLH in the kerosene light trap indicated a gradual increase in GLH activity in the area (see figure).

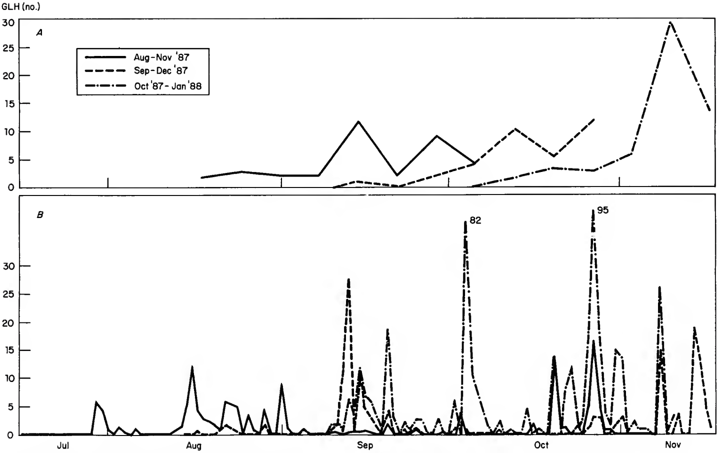
Although RTV infection in general was too low to cause significant yield loss, RTV incidence tended to increase from the first planting to the third.

Because of negligible pest incidence, yield from the first planting was significantly higher than that from the second and third plantings. High thrips incidence during the vegetative stage of the second planting and high incidence of caseworm and rice bug coupled with severe damage by rats in the third planting contributed to lower yields. □

**Pest incidence and yield on sequentially planted IR64 crops.[a] Sierra Bullones, Bohol, Philippines, 1987-88.**

| Cropping period | Rat damage | GLH (mean/3 wk, 10 sweeps each) | Rice bugs (no./m$^2$) | Caseworm (larvae/m$^2$) | Thrips (no./leaf) | Yield (t/ha + SEM) |
|---|---|---|---|---|---|---|
| Aug-Nov 1987 | Negligible | 14 a | 0 | 0 | 0 | 6.1 + 0.31 a |
| Sep-Dec 1987 | Negligible | 13 a | 0 | 0 | 9 | 5.4 + 0.25 b |
| Oct 1987-Jan 1988 | Severe | 26 b | 18 | 11 | 0 | 2.6 + 0.08 c |

[a]In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.




Seasonal population density of GLH monitored by sweep net and kerosene light trap (KLT). Hopper numbers are based on(A) weekly catches in 10 sweeps made on sequentially planted crops of IR64 and on (B) daily catches in KLT. Sierra Bullones, Bohol, Philippines, 1987.

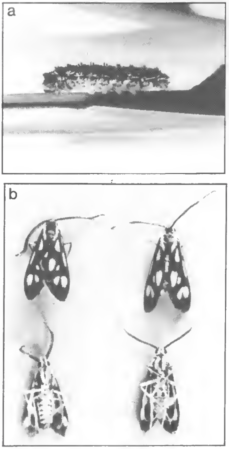
## A new observation of rice defoliator in Nepal

*S. B. Pradhan, Entomology Division, Khumaltar Agriculture Station (KAS), Kathmandu, Nepal*

A new pest of rice *Amata nr fortunei* Del'orza of the family Amatidae was observed Aug-Sep 1985 in the field and in the greenhouse at KAS. Infestation was much more severe in the greenhouse.

Both sexes are small black moths with yellow markings (see figure). The adult male is 1 cm long with black, feathery antennae; the female is 1.1 to 1.2 cm long with straight antennae.

Larvae are black with white hairs. Maximum length of the full-grown larva is 1.5 cm. The larvae coil their bodies and hang in a silken thread when disturbed. They are solitary and in the early stages feed on chlorophyll of the rice leaves in parallel lines, giving the impression of hispa or leptispa damage. In later instars, the larvae feed on all the leaf but the midrib. Overall damage is similar to that of armyworm.




Larva (a) and adults (b) of *Amata nr fortunei*, family Amatidae, found in Nepal.

Pupation takes place within a papery cocoon at the base of the rice plant or on any nearby object. The moth emerges in 14-17 d. The female lays its egg in the morning in nonoverlapping chains. Eggs are oval and creamy white. They were observed on both surfaces of rice leaves as well as on other objects.

Specimens were identified by A. T. Barrion, Entomology Department, IRRI. □

## Effect of silicate materials on rice crop pests

*S. Subramanian and A. Gopalaswamy, Agricultural College and Research Institute, Madurai 625104, India*

We assessed the effect of sodium metasilicate (48.5% $SiO_2$), furnace slag (20.2% $SiO_2$), and rice husk (14.5% $SiO_2$) at 1 t $SiO_2$/ha on incidence of rice thrips *Stenchaetothrips biformis* (Bagnall), rice gall midge (GM) *Orseolia oryzae* Wood-Mason, and leaffolder (LF) *Cnaphalocrocis medinalis* Guen.

Experimental soil was sandy clay loam with pH 7.0, EC 0.25 dS/m, 0.72% organic C, and 55.4 ppm available Si (N.NaOHC, pH 4.0).

Rice husk, furnace slag, and sodium metasilicate significantly reduced the thrips population (see table). Although silicate materials did not have much influence on GM incidence at tillering, a significant decrease was observed at panicle initiation. The addition of silicate materials also reduced LF incidence during panicle initiation.

Rice husk was superior to furnace slag and sodium metasilicate in reducing LF incidence. □

**Effect of silicate materials on incidence of rice pests. Tamil Nadu, India, 1985.**

| Treatment | Tillering | | Panicle initiation | |
|---|---|---|---|---|
| | Thrips (no./leaf) | Gall midge (%) | Gall midge (%) | Leaffolder (%) |
| Control | 10 | 11.3 | 24.7 | 28.0 |
| Sodium metasilicate | 6 | 9.8 | 23.1 | 21.8 |
| Furnace slag | 6 | 10.7 | 18.2 | 18.7 |
| Rice husk | 7 | 10.0 | 20.4 | 18.0 |
| LSD (0.05) | 1 | ns | 2.2 | 2.3 |

## A rearing technique for *Conocephalus longipennis* (de Haan) (Orthoptera: Tettigoniidae)

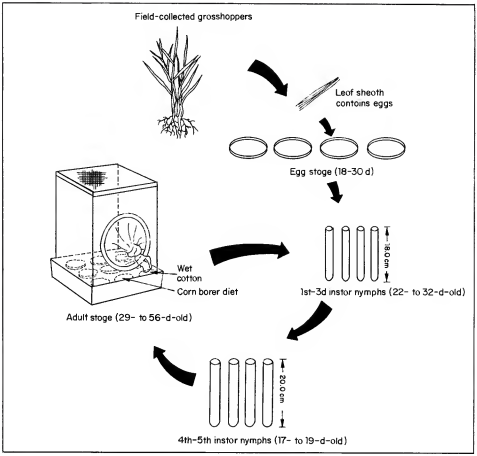
*E. G. Rubia and B. M. Shepard, Entomology Department, IRRI*

The grasshopper *C. longipennis* common in ricefields is considered a predator, but it has been shown to attack rice, especially developing grains. It has also been observed to feed on rice foliage and flowers.

As a predator, it attacks the eggs of rice bugs, stem borers, and leaffolders and the nymphs and adults of hoppers, leaffolders, and whorl maggots.

To study its status as a predator or as a pest, a rearing method was needed.

Field-collected adult *C. longipennis* were confined on 45-d-old TN1 rice plants (see figure). Leaf sheaths bearing eggs were cut from rice plants and transferred to petri dishes lined with moist filter paper. Newly emerged first instars were transferred individually (to prevent cannibalism) to 15.0-cm test tubes (1.6 cm in diameter) and provided with southwestern corn borer diet.




Rearing field-collected grasshoppers in the laboratory.

**Survival of *C. longipennis* using the mass rearing technique. IRRI insectary, 1986.**

| Stage | Insects reared (no.) | Surviving individuals (no.) | survival (%) |
|---|---|---|---|
| Egg to 1st instar | 326 | 307 | 96 |
| 1st instar to adult | 40 | 34 | 85 |

Third instars were transferred to 20.0-cm test tubes (2.5 cm in diameter) to complete nymphal development. Newly emerged adult males and females were confined in 30- × 22- × 52.5-cm rectangular mylar cages with separate petri dishes containing 2 g of corn borer diet and moist cotton on the bottom. The moist cotton provided water and served as a suitable substrate for oviposition.

*C. longipennis* completed its life cycle from egg to adult in 142 to 182 d, with 80% survival (see table). The corn borer diet was suitable for rearing the insect. □

## Effect of insecticides on rice leaffolder (LF) eggs

*N. Raju, M. Gopalan, and G. Balasubramanian, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore 641003, India*

We studied nine insecticides to determine their ovicidal efficacy on eggs of LF *Cnaphalocrocis medinalis* (Guenée) in the insectary. The experiment was in a completely randomized design with three replications, with each replication consisting of 20 eggs.

Male and female LF moths obtained from mass culture were introduced in tumbler pots containing 25-d-old rice seedlings. The tumbler pots were covered with glass chimneys 22 cm high and 7.5 cm in diameter. Oviposition was observed daily. Seedlings containing eggs were separated and planted in tumbler pots.

Insecticidal treatments were given with a hand atomizer; control pots received water spray. Hatching of larvae was recorded for each treatment.

Phosphamidon, quinalphos, and monocrotophos treatments had 100% egg mortality; fenthion followed with 96% mortality (see table). Endosulfan exhibited the least ovicidal action. □

**Ovicidal action of insecticides on rice LF eggs. Coimbatore, India.**

| Insecticide | Concn. (%) | Mortality[a] (%) |
|---|---|---|
| Monocrotophos 36 WSC | 0.05 | 100 a |
| Quinalphos 25 EC | 0.05 | 100 a |
| Phosphamidon 85 WSC | 0.045 | 100 a |
| Fenthion 100 EC | 0.01 | 96 a |
| Chlorpyrifos 20 EC | 0.04 | 54 b |
| Malathion 50 EC | 0.1 | 46 b |
| Dichlorvos 100 EC | 0.02 | 42 b |
| Carbaryl 50 WP | 0.1 | 42 b |
| Endosulfan 35 EC | 0.07 | 21 c |
| No insecticide (control | Water spray | 11 d |

[a]Means followed by a common letter are not significantly different (P=0.05) by DMRT.

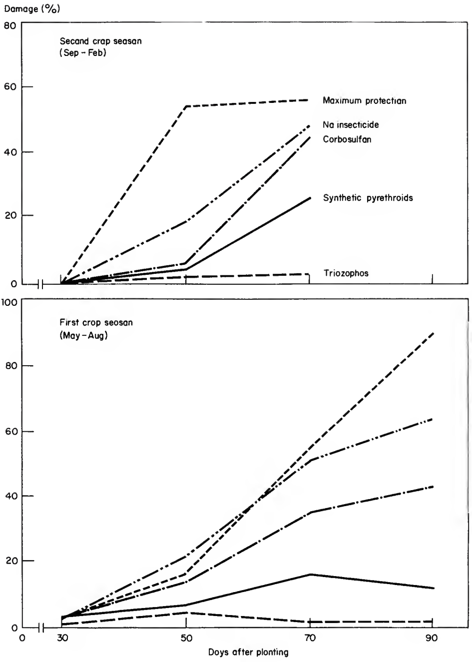
## Leaffolder (LF) resurgence and species composition in Pattambi, Kerala

*L. Nadarajan and B. P. Skaria, Regional Agricultural Research Station (RARS), Pattambi, Kerala 679306, India*

In field trials 1983-85 at Pattambi, LF damage was higher in maximum protection treatments (MPT) (see figure). In both the first crop (May-Aug) and second crop (Sep-Feb), MPT plots receiving carbofuran at 1 kg ai/ha 20, 40, and 60 d after transplanting (DT) recorded higher LF damage (90% in the first crop, 55% in the second) than the no-insecticide plot.

Triazophos effectively controlled LF. Carbosulfan was no different from no insecticide. With synthetic pyrethroid, damage was 10-25%.

To corroborate these findings, we conducted an observational trial in 90-$m^2$ plots using EC (emulsifiable




LF damage in Kerala, India, 1983-85.

**Control of LF resurgence on variety Annapoorna. Kerala, India, 1983-85.**

| Insecticide | Application method | Rate (kg ai/ha) | Damaged leaves[a] (%) 29 DT[b] | 44 DT[c] | 60 DT |
|---|---|---|---|---|---|
| Chlorpyrifos 20 EC | Foliar | 0.5 | 17.9 | 14.9 | 2.7 |
| Quinalphos 25 EC | Foliar | 0.5 | 18.3 | 6.7 | 0.6 |
| Carbofuran 3 G | Soil | 0.75 | 7.3 | 56.5 | 72.5 |
| Quinalphos 5 G | Soil | 0.75 | 10.4 | 50.6 | 52.5 |
| Phorate 10 G | Soil | 0.75 | 10.6 | 34.4 | 45.2 |
| Monocrotophos 40 EC | Foliar | 0.5 | 14.7 | 10.3 | 3.4 |
| No insecticide (untreated control) | – | – | 17.7 | 65.8 | 70.0 |

[a]Computed from 25 infested hills in each treatment. Insecticides applied 30 and 45 DP. [b]1 d before first application. [c]1 d before second application.

concentrate) and granular insecticide formulations applied at 30 and 45 DT. The results confirmed that, in general, granular insecticide formulations are less effective than EC formulations (see table).

Carbofuran had controlled LF earlier, but resurgence was evident recently. Samples of LF larvae were collected from ricefields and reared in the laboratory. Adults that emerged were identified by wing markings. Adults collected from light traps also were identified.

An estimate for 3 mo Oct to Dec showed that about 50% of the LF population was *Marasmia patnalis* Bradley, which had not been reported in this region before. The rest of the population was common LF *Cnaphalocrocis medinalis* Guenée. ☐

## Occurrence and infectivity of entomogenous nematodes in mole crickets in Brazil

*H. G. Fowler, Instituto de Biociências, UNESP, 13500 Rio Claro, SP, Brazil*

In certain regions of the Amazon, mole crickets of the genera *Scapteriscus* and *Neocurtilla* are major pests of rice planted on seasonal floodplains. Although nematodes have been isolated previously from Brazilian mole crickets, work since 1982 on natural enemies has revealed 18 isolates of *Steinernema felitae* (Filipjev) (*Neoaplectana carpocapsae* Weiser) and 13 isolates of *Heterorhabitis* sp. from 1,532 site collections.

Site collections consist of digging mole crickets from each sampled locality and field. Site collections ranged from 1 to more than 500 crickets.

In initial laboratory evaluations, it was impossible to propagate the nematodes on the wax moths *Galleria* sp. usually used for mass production. We screened mole crickets that had been held in the laboratory at least 30 d to ensure they were not infested with nematodes or other pathogenic agents and exposed them to nematodes on

moist filter paper in petri plates. A minimum 50% mortality was obtained from all isolates, and at least 70% for *S. felitae* isolates. There was no mortality in untreated crickets.

In tests using the same methods with other lepidoptera and hymenoptera, such as honey bees and ants, mortality was less than 10%. Using the methods with field crickets *Gryllus* sp. and short-tailed crickets *Anurogryllus* sp. gave infectivity rates in excess of 50%.

These results indicate that these nematode strains are highly host-specific and extremely infective to mole, field, and short-tailed crickets. As these strains were isolated from sandy riverbanks and from mole cricket populations, their potential use for the major pest species of the Amazon, *Scapteriscus didactylus* Scudder, as well as for locally troublesome species of mole crickets seems highly promising, especially in the Amazon, where mole cricket densities are high, and there are no registered control insecticides. ☐

## Neem seed kernel or neem cake powder and carbofuran granule mixture for controlling green leafhopper (GLH) and rice tungro virus (RTV)

*A. A. Kareem, M. E. M. Boncodin, and R. C. Saxena, Entomology Department, IRRI*

Carbofuran granules at 2 kg ai/ ha are often applied as a prophylactic measure to rice in RTV-prone areas. Insecticidal control relying on economic threshold levels for the vector GLH *Nephotettix virescens* (Distant) is risky.

Neem seed derivatives have been found to reduce GLH feeding and RTV transmission. They reportedly possess antimicrobial activity that may reduce the degradation of carbofuran in flooded rice soils.

We tested neem seed kernel and neem cake powder mixed with carbofuran at 1 kg ai/ha (33.3 kg neem powder: 33.3 kg Furadan 3G) against carbofuran at 2 kg ai/ha (66.6 kg Furadan 3G). Because neem trees are widespread in many rice-growing countries, neem-carbofuran mixtures could appreciably reduce the cost of purchased inputs for RTV management.

Powdered neem seed kernel and cake from 1987 harvest were mixed separately (1: 1 wt/ wt) with carbofuran in polythene bags. The neem-carbofuran mix or carbofuran alone was applied at 2 kg ai/ha to 1-mo-old potted GLH- and RTV-susceptible TN1 rice plants. Untreated plants and plants treated with carbofuran at 1 kg ai/ ha were the controls.

At 24 h after treatment, 5 pairs of viruliferous GLH males and females were caged on treated and control plants. Insect mortality was measured 72 h after infestation and used GLH adults were removed and replaced with 5 pairs of fresh viruliferous adults. Insect mortality was measured 72 h after reinfestation. Nymph emergence was observed daily from 1 wk after first infestation to 10 d after reinfestation. RTV infection based on visual symptoms was measured 20 d after reinfestation.

Insect mortality was 98-100% with carbofuran alone, 96-100% in the neem-carbofuran mixtures, and 0 in the control (see table). Nymph emergence in the carbofuran treatments significantly differed from that in the control. Carbofuran mixed with neem seed kernel powder was most effective against RTV, keeping infection to 2%. ☐

**Mortality of GLH adults, nymph emergence, and RTV infection in TN1 plants treated with carbofuran mixed with neem seed kernel (NSK) or neem cake (NC) powder or with carbofuran alone.[a] IRRI, 1987.**

| Treatment | Adult mortality (%) in infestations | | Nymphs emerged (no.) | RTV infection (%) |
|---|---|---|---|---|
| | 1st | 2d | | |
| Carbofuran (1 kg ai/ha) + NSK (1:1) | 100 a | 100 a | 0 a | 2 a |
| Carbofuran (1 kg ai/ha) + NC (1:1) | 98 a | 96 a | 0 a | 8 b |
| Carbofuran (2 kg ai/ha) | 100 a | 100 a | 0 a | 10 b |
| Carbofuran (1 kg ai/ha) | 100 a | 98 a | 4 b | 28 c |
| Untreated (control) | 0 b | 0 b | 285 c | 100 d |

[a]In a column, means followed by a common letter are not significantly different at 5% level by DMRT. Av of 5 replications.

## Sensitivity of different stages of *Leptocorisa oratorius* (Fabricius) to monocrotophos

*L. T. Fabellar and O. Mochida, Entomology Department, IRRI*

Nymphs and adults of *L. oratorius,* the most widely distributed rice bug species, damage rice from flowering through the dry dough stage, A common control method is the use of insecticides. To be more efficient, insecticide should be applied not only at the stage when the pests do the most damage to rice, but also when the insects are most sensitive to the treatment. We tested five nymphal instars and female adults to determine the insect stage most sensitive to insecticides.

Insects collected in vials from culture cages were anaesthetized with $CO_2$.

**$LD_{50}$, values for reaction of different life stages of *Leptocorisa oratorius* to monocrotophos. IRRI, 1987.**

| Stage | $LD_{50}$[a] | |
|---|---|---|
| | µg/g | µg/insect |
| First instar | 0.52 c | 0.70 a |
| Second instar | 0.62 c | 1.70 b |
| Third instar | 0.56 c | 4.85 c |
| Fourth instar | 0.89 d | 16.24 e |
| Fifth instar | 0.37 b | 39.11 f |
| Adult female | 0.06 a | 9.13 d |

[a]$LD_{50}$s followed by a common letter are not significantly different at the 5% level by DMRT.

Monocrotosphos was applied topically at 0.5 µl, using a Burkard microapplicator with calibrated microsyringe. Treated insects were transferred to rice panicles of plants enclosed in mylar cages. The test had 10 insects/treatment with 4 replications.

Cages were kept in the phytotron at 27-30 °C, 60-80% relative humidity, and 12 h illumination. Mortality was recorded 24 h after treatment. $LD_{50}$ values were computed using probit analysis.

The lowest $LD_{50}$ value (µg/g) was for adult females and the highest for the 4th instar (see table). Regardless of body weight, the adult was more sensitive than the 4th and 5th instar. Lower insecticide dosages will control adults; higher dosages may be needed to control nymphs. □

## Susceptibility of brown planthopper (BPH) and green leafhopper (GLH) to insecticides under different temperatures

*L. T. Fabellar and O. Mochida, IRRI*

When $LD_{50}$ values are compared between locations, prevailing temperature could cause inconsistent results. We subjected BPH and GLH to six different temperatures after topical insecticide application.

Serial dosages of 7 insecticides were prepared in acetone solution and 0.1 µl and applied on the thoracic tergites of anaesthetized BPH and 0.2 µl on those of GLH. Twenty treated adults were placed in a plastic tumbler, provided with 10 two-week-old seedlings for food, and transferred in Koitotron cabinets set at constant temperatures of 18 °C to 33 °C with natural daylength. Insect mortality was recorded 24 h after treatment and $LD_{50}$ values were computed using probit analysis.

BPH and GLH were susceptible to most of the insecticides at higher temperatures and to the pyrethroids at lower temperatures (see table). For BPH, all insecticides except cypermethrin and deltamethrin had lower $LD_{50}$ values at 33 °C than at 18 °C (see table). For GLH, all insecticides except carbaryl and the two pyrethroids were more potent at higher temperatures. Insecticide activity was comparable at the temperature range 27-30 °C. Temperatures before, during, and after treatment should be recorded to control their possible effect on insecticide activity. □

**$LD_{50}$ values of BPH brachypterous adult females and GLH adult females at 6 temperatures.[a] IRRI phytotron, 1987.**

| Temp (°C) | $LD_{50}$ (µg/g) in 24 h | | | | | | |
|---|---|---|---|---|---|---|---|
| | BPMC | Carbaryl | Carbofuran | Cypermethrin | Deltamethrin | Diazinon | Malathion |
| | | | | *BPH* | | | |
| 18 | 4.68 a | 4.12 a | 1.19 a | 0.24 a | 0.40 a | 12.13 a | 37.43 a |
| 21 | 2.59 b | 4.64 a | 0.85 ab | 0.25 a | 0.53 a | 8.36 a | 23.95 a |
| 24 | 1.92 b | 3.91 a | 0.74 abc | 0.29 a | 0.46 a | 8.46 a | 27.02 a |
| 27 | 1.30 b | 3.78 a | 0.37 bc | 0.33 a | 0.57 a | 6.76 a | 14.38 a |
| 30 | 1.70 b | 4.08 a | 0.39 bc | 0.42 a | 0.55 a | 7.05 a | 13.95 a |
| 33 | 0.61 b | 1.67 b | 0.21 c | 0.39 a | 0.59 a | 4.92 a | 9.08 a |
| | | | | *GLH* | | | |
| 18 | 6.85 a | 4.38 a | 3.42 a | 0.14 b | 0.12 b | 36.20 a | 11.83 a |
| 21 | 7.00 a | 5.38 a | 2.88 ab | 0.21 ab | 0.27 b | 27.61 b | 12.05 a |
| 24 | 4.40 ab | 4.54 a | 2.03 bc | 0.14 b | 0.54 ab | 23.78 b | 12.25 a |
| 27 | 3.49 b | 5.62 a | 1.61 bc | 0.25 ab | 0.75 a | 19.04 b | 9.62 ab |
| 30 | 2.30 b | 3.70 a | 1.68 bc | 0.58 a | 0.75 a | 19.10 b | 9.31 ab |
| 33 | 1.66 b | 4.41 a | 1.17 c | 0.57 a | 0.71 a | 19.36 b | 6.99 b |

[a] Av of 3 replications, 20 insects/replication. In a column within a species, means followed by a common letter are not significantly different at the 5% level by DMRT.

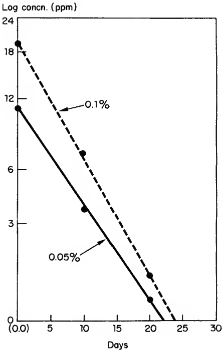
## Residues of quinalphos in rice

*H. K. Senapati, S. K. Mohanty, A. K. Pal, and M. R. Pattnaik, Pesticide Residues Laboratory, Soils and Agricultural Chemistry Department, Orissa University of Agriculture and Technology, Bhubaneswar 751003, India*

We studied residues of quinalphos (0, 0-diethyl-D-[2-quinoxalyl] phosphorothionate), widely used insecticide, in rice variety Lalat (ORS26-2014). The pesticide was sprayed at the recommended level (0.05%, or 0.25 kg ai/ ha) and double the recommended level (0.1%, or 0.50 kg ai/ha). Plant samples were collected at 0, 10, 20, and 30 d after spraying and at harvest.

The spectrophotometric method was used to estimate residues of quinalphos, using p-nitrobenzyl pyridine as the chromogenic reagent. Recovery of quinalphos from fortified plant samples was 86-87%.

Mean initial residues of I 1.04 ppm (0.05%) and 18.86 ppm (0.1%) were reduced to 3.45 and 6.86 ppm 10 d after insecticide application, to 0.62 and 1.05 ppm 20 d after application, and to nondetectable levels 30 d after




Linear plot of first-order reaction of quinalphos in rice. Bhubaneswar, India.

application. Dissipation was 94.4% (0.05% and 0.1%) 20 d after application.

Rate of degradation with both applications seemed to follow the first-order reaction (see figure).

Fifty percent of the toxicant was reduced at 1.4 d and 1.95 d and the safe waiting period ($T_{tol}$) was 15.9 d and 17.5 d for lower and higher applications.

Grain and straw samples had nondetectable levels of quinalphos. □

## Effect of plant age on rice susceptibility to yellow stem borer (YSB) *Scirpophaga incertulas* (Walker)

*V. D. Viajante and R. C. Saxena, Entomology Department, IRRI*

YSB, the most important of the 21 species of stem borers that attack rice, is widespread in tropical Asia and Japan. All rice crops, whether irrigated, lowland rainfed, upland, or deepwater, suffer damage. Adults oviposit on leaves and newly emerged larvae enter stems and feed on the inner walls, causing deadhearts at the vegetative stage and whiteheads at the reproductive stage.

We studied larval survival and degree of damage on rice plants of different ages. Seeding of IR64 was staggered so plants of different ages were available for simultaneous infestation with first-instar larvae. There were 12 pots/age group. Plants were thinned to 20 tillers/pot. Each pot was infested with 15 larvae hatched from field-collected egg masses and then covered with a 40- × 100-cm mylar film cage.

Four pots were dissected at 18 d and 4 pots at 25 d after infestation (DAI). Adults were allowed to emerge on four pots.

Larvae recovered by dissecting plants at 18 DAI were weighed individually. Individuals recovered from plants at 25 DAI could not be weighed as some had reached the prepupal stage. The remaining plants were cut about 20 cm above the soil for easy observation of emerging adults.

**Survival and development of *S. incertulas* larvae and damage at different days after infestation (DAI) on IR64 plants of different ages.[a] IRRI, 1987.**

| Plant age (DAS) | Larval wt (mg/larva) 18 DAI | Survival (%) | | Adults emerged (no.) | Deadhearts (%) | |
|---|---|---|---|---|---|---|
| | | 18 DAI | 25 DAI | | 18 DAI | 25 DAI |
| 10 | 0 e | 0 d | 1 d | 0 d | 10 c | 9 e |
| 16 | 7.8 d | 2 cd | 2 cd | 0 d | 22 b | 12 d |
| 22 | 8.9 d | 2 cd | 4 cd | 0 d | 25 b | 14 d |
| 28 | 12.8 c | 4 c | 5 c | 5 c | 27 b | 16 cd |
| 34 | 34.1 ab | 68 a | 55 a | 33 b | 69 a | 66 ab |
| 40 | 41.2 a | 68 a | 52 a | 63 a | 69 a | 11 a |
| 46 | 33.3 ab | 37 b | 49 a | 48 b | 57 a | 56 b |
| 52 | 29.8 b | 28 b | 28 b | 41 b | 27 b | 26 c |

[a]Av of 4 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Fewer larvae survived and emerged on younger rice plants (see table). Survival increased with plant age up to 34 and 40 d after sowing (DAS), then declined progressively on plants aged 46 and 52 DAS. Fewer deadhearts were observed in younger plants than in plants at 34, 40, and 46 DAS; deadheart count declined sharply at 52 DAS. Larvae were heaviest on plants at 40 DAS; they weighed less on plants at 34, 46, and 52 DAS. □

## Fecundity of several green leafhopper (GLH) populations in Indonesia

*I. G. P. A. Diratmaja, Bogor Research Institute for Food Crops (BORIF), Indonesia*

A greenhouse experiment Jan-Apr 1985 was designed to study the fecundity of GLH *Nephotettix virescens* Distant populations from four sites in Indonesia: Salutete and Pangkajene (South Sulawesi), Tawamalewe (South East Sulawesi). and Citamiang (West Java).

A pair of mature GLH was placed in a test tube containing a 2-wk-old TN1 seedling. Number of eggs laid was counted daily under the microscope. Fecundity differed in the four locations (see table). □

**Fecundity of *N. virescens* Distant from four Indonesian populations[a], 1985.**

| Origin of population | Pre-oviposition period (d) | Oviposition period (d) | Postoviposition period (d) | Eggs (no.) |
|---|---|---|---|---|
| Salutete | 6 a | 23 a | 2 a | 260 a |
| Pangkajene | 8 a | 11 b | 2 a | 81 c |
| Tawamalewe | 7 a | 18 ab | 2 a | 151 bc |
| Citamiang | 6 a | 22 a | 1 a | 213 ab |

[a]In a column, means followed by a common letter are not significantly different at the 5% level.

## Effect of sweep-net sampling at rice crop reproductive stage on yield

*E. G. Rubia, A. A. Lazaro, and B. M. Shepard, IRRI*

Orthopteran predators such as *Metioche vittaticollis*, *Anaxipha longipennis*, and *Conocephalus longipennis*, as well as certain pests such as rice bugs and green leafhoppers often are abundant in fields where rice plants are at the reproductive stage. Sweep-net sampling, an efficient method of collecting these highly mobile insects in the field, might damage the flowering plants and affect yields. Yet it is important to sample insects to make

appropriate management decisions.

We set up a trial to determine possible effects of sweep-net sampling on rice yields. IR62, IR64, and IR1917-3-17 were transplanted 20 d after seeding at 25 × 25 cm. Each field was divided into 24 6.25- × 8.3-m plots. Four treatments were replicated six times in a randomized complete block design.

We sampled weekly for 3 consecutive weeks starting at 67 d after transplanting (DT), making 1, 3, or 6 passes through a plot. The sampler made 10 sweeps/ pass.

**Effect on yield of sweep-net sampling for 3 consecutive weeks beginning 67 DT. IRRI, 1987.**

| Passes through the plot (no.) | Yield[a] (t/ha) | | |
|---|---|---|---|
| | IR62 | IR64 | IR1917-3-17 |
| 0 | 3.7 a | 3.8 a | 3.2 a |
| 1 | 3.2 ab | 3.6 a | 3.2 a |
| 3 | 3.2 ab | 3.7 a | 3.0 b |
| 6 | 3.0 b | 3.6 a | 2.8 b |

[a]Av of 6 replications. In a column, means followed by a common letter are not significantly different at the 10% level by DMRT.

There was no significant difference in yields of IR64 from the different sweep-net pass patterns (see table). However, sterile spikelets at harvest should be evaluated. From 0 to three passes through IR62 did not significantly affect yields, but 6 passes did. Yield of IR1917-3-17 decreased with 3-6 passes. One pass through the field did not significantly affect yield of any variety. □

## Leaffolder (LF) outbreak in Haryana

*G. A. Qadeer, S. P. Arya, and O. S. Tomer, Central Surveillance Station, India Ministry of Agriculture, Karnal, Haryana, India*

LF *Cnaphalocrocis medinalis* (Guenée) has been observed in most rice-growing areas of Haryana, but its incidence has been below the economic threshold. Our regular pest monitoring surveys now show that since 1983, LF has started to cause significant damage to the rice crop. A severe outbreak was observed during 1987 kharif (Jul to mid-Oct).

We surveyed extensively during 1987 to monitor LF in the major crop areas—Kurukshetra, Karnal, Ambala, Jind, Sirsa, and Sonepat. Peak incidence was in mid-September when rice was at the panicle emergence stage. In 13 of 145 villages surveyed, 1-5% leaves were found damaged; in 28 villages, 5-25%; in 44 villages, 50%; and in 60 villages, more than 50%. Populations ranged from 2 to 20 larvae/hill. PR106 and Basmati 370 were the most affected rice varieties.

The nitrogenous fertilizer recommendation for these ricefields is 100-140 kg N/ ha. Excessive application of nitrogenous fertilizer, coupled with indiscriminate application of granular pesticides and other formulations, could have resulted in resurgence.

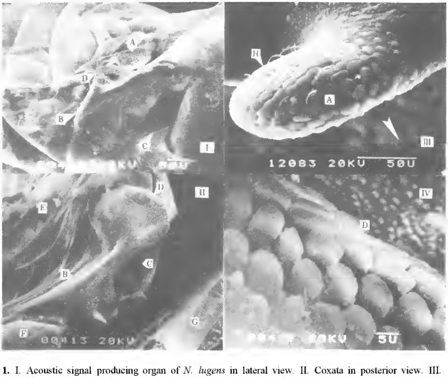
Average monsoon rainfall is 500-750 mm during kharif. But in 1987 kharif, unprecedented drought Jul-Oct could have affected the insect population. □

## Acoustic signal-producing organ of brown planthopper (BPH)

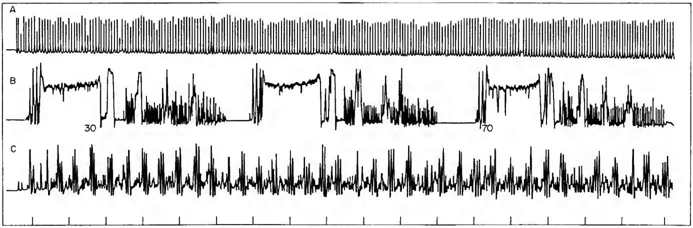
*Z. T. Zhang and W. Z. Kong, Plant Protection Department, China National Rice Research Institute; J. L. Gao and T. H. Shao, Central Laboratory, Jiangsu Agricultural College, China*

Prior to copulation, both male and female adults of the rice BPH communicate primarily by means of acoustic signals emitted by specialized signal-producing organs. We investigated the structure and function of those organs.

The signal-producing organ (possessed only by the adults) is situated on both sides of the juncture of the pterothorax and abdomen (Fig. 1). It is composed of a sclerotizing coxata and a petal-like sclerite extended in the front of the third sternopleuron (the first and second sternopleuron are under-developed and invisible). The underside




1. I. Acoustic signal producing organ of *N. lugens* in lateral view. II. Coxata in posterior view. III. Petal-like sclerite in the front of third sternopleuron in anterior view, arrow points upward. IV. Flaky processes on the top of coxata. A = petal-like sclerite, B = coxata, C = a hole before coxata, D = the top of coxata covered with flaky processes, E = pterothorax, F = trochantin, G = femur, H = underside of the sclerite.




**2.** Acoustic courtship signals of *N. lugens.* A. Female (macropterous or long-winged) signal. B-C. Male (macropterous or long-winged) signal. Time marks at 1-S intervals, RC: 0.007 s.

of the sclerite and the top of coxata are densely covered with rectangular chitinous scales.

As a calling adult slightly vibrates its abdomen in a dorsoventral direction, the sclerite rubs against the top of the coxata. The acoustic signal emitted is a series of clicks or discrete sound pulses (Fig. 2).

This signal-producing mechanism was verified in an experiment where adults with the two friction surfaces topically glued were unable to call.

The wave pattern, pulse repetition frequency, and sonic spectrum of the signals are closely related to the abdominal action and acoustic characteristics of the insect body. There is, however, no significant variation in those aspects between macropters and brachypters.

The acoustic signal is transmitted through the substrate of the host plant, making it possible for a small insect such as BPH to transmit a faint audio-frequency signal; transmitting efficiency is much higher than through air. The legs, and sometimes the feeding stylet, are believed to be the connection from the insect to the host plant for transmission and reception. No special hearing organ has been found, even under scanning electron microscope. Perhaps BPH responds to the signals through tactile sensations in its legs.

Several species of other common planthoppers — *Sogatella furcifera* (Horvath), *S. longifurcifera* (Esaki et Ishihara), *Laodelphax striatellus* (Fallen), *Nilaparvata bakeri* (Muir), *N. muiri* China, *Paracorhulo sirokata* (Matsumura et Ishihara), *Toya propinqua neopropinqua* (Muir), and *Saccharosydne procerus* (Matsumura)— have similar acoustic signal-producing organs. BPH is considered to be representative of delphacids. □

## Occurrence of flour mite *Acarus siro* Linn. in rice mills

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*A. siro* (*Tyroglyphus furinae* Linn.), a polyphagous flour mite, was reported for the first time in milled rice samples collected from storage godowns in Cuttack, Puri, and Balasore districts of Orissa 1984-86. We examined 25-g samples under stereoscopic binocular microscope to determine mite population (eggs, juveniles, and adults). Grain moisture content of each sample was measured by the Oswa Universal Moisture Meter.

Stored rice harbored a range of mite populations, depending on storage period, rice variety, and grain moisture. Mite populations showed significant differences among four test varieties— CR1014, Ratna, Jaya, and Pusa 2-21 (see table).

The mite occurred in almost all samples collected from 10 rice mills. Mite populations increased significantly across storage from 6 to 24 mo. Grain moisture of the samples ranged from 16 to 19%, considered a congenial moisture range for mite multiplication. In addition, the mite was found in such rice products as bran and suji (powdered rice) stored in godowns of the mills. □

**Population of flout mite in milled rice. Orissa, India, 1984-86.**

| Storage period (mo) | Mites[a] (no./25-g sample) | | | |
|---|---|---|---|---|
| | CR1014 | Ratna | Jaya | Pusa 2-21 |
| 6 | 86 a | 73 a | 65 a | 39 a |
| 12 | 158 b | 139 b | 128 b | 47 ab |
| 18 | 183 bc | 152 bc | 148 c | 110 c |
| 24 | 284 d | 228 d | 253 d | 149 d |

[a]Mean of 20 samples. Means followed by a common letter are not significantly different at the 5% level by DMRT.

## Effect of prevailing temperature and humidity on rice armyworm reproduction during upland crop season

*R. Singh, Entomology Department, Haryana Agricultural University, Hisar 125004, India*

Rice armyworm *Mythimna loreyi* (Dup.) migrates from rice to other cereal crops in areas where multiple cropping is the practice and climatic variations are extreme. In North India, it attacks rice Jun-Nov, then migrates to wheat, barley, sugarcane, oat, and napier Dec-May.

To study the effect of prevailing Dec-May temperature and humidity on its reproductive biology, we used adults from the mass culture raised in the laboratory at 26±1 °C in BOD incubators. Each month, 15 freshly emerged pairs (male + female) were released separately in glass jars (15 × 10 cm) with muslin cloth covers. Dry sugarcane leaves kept in jars for egg laying were renewed daily after initiation of oviposition. A sucrose solution (10%)-soaked cotton swab provided for feeding.

Females always survived longer (4.5-21.2 d) than males (4.0-11.0 d) (see table). In spite of a longer oviposition period (10-11 d) during Dec-Jan, females laid fewer eggs (75-95 eggs/female) and more infertile ones because of low temperature. Rising temperatures (9-26 °C) in Feb enhanced fecundity and hatching. During Mar (12-32 °C) and Apr (18-36 °C), temperature considerably reduced the oviposition period (4-5 d) compared to Dec-Jan (10-11 d) but increased fecundity about 3 times, with 29.4-42.4% hatching. Average daily egg output was also higher during Feb-Apr than during Dec-Jan. In May, high temperature (24-42 °C) significantly reduced adult longevity and fecundity. Eggs laid in May did not hatch.

In December and March relative humidity was almost the same, indicating its insignificant role. During the experimental period, however, optimum conditions (25-30 °C and 75-85% RH) never prevailed, resulting in poor overall fecundity and egg viability. It appears that rice armyworm reproduction is most affected by temperature. □

**Effect of prevailing temperature and humidity on reproductive activity of rice armyworm adults.[a] Hisar, India.**

| Month | Temperature (°C) | | Relative humidity (%) | Pre-oviposition period (d) | Oviposition period (d) | Postoviposition period (d) | Adult longevity (d) | | Eggs (no./ female) | Eggs (no./d) | Incubation period (d) | Hatching (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | | | | | Male | Female | | | | |
| Dec | 18±2.3 | 8±1.5 | 59±5.2 | 10.0 | 10.0 | 1.0 | 10.0 | 21.0 | 75 | 7.5 | – | – |
| Jan | 20±2.1 | 6±2.4 | 70±4.5 | 9.8 | 11.0 | 0.5 | 9.0 | 21.2 | 95 | 8.6 | – | – |
| Feb | 26±2.8 | 9±3.0 | 57±4.0 | 6.5 | 5.5 | 1.2 | 11.0 | 13.0 | 320 | 58.2 | 7.5 | 22.6 |
| Mar | 32±2.9 | 12±3.0 | 57±3.5 | 5.0 | 5.0 | 2.0 | 8.0 | 12.0 | 253 | 50.6 | 5.0 | 42.4 |
| Apr | 36±2.0 | 18±2.4 | 45±2.8 | 3.0 | 4.0 | 1.0 | 5.5 | 8.0 | 276 | 69.0 | 4.6 | 29.4 |
| May | 42±4.0 | 24±3.0 | 36±3.0 | 3.0 | 1.0 | 0.5 | 4.0 | 4.5 | 15 | 15.0 | – | – |
| LSD (0.05) | | | | 2.4 | 1.6 | 0.6 | 2.3 | 3.4 | 56 | 13.5 | 1.3 | 10.6 |

[a]Av of 15 replications, 1 pair (female + male) of adults/replication.

## Chemical control of whitebacked planthopper (WBPH)

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WBPH *Sogatella furcifera* has become a major pest in both dry and wet season rice in western Orissa. Peak activity during booting causes high yield loss.

We evaluated seven insecticides for WBPH control in the field, in a randomized block design with three replications. Jaya seedlings (35 d old) were transplanted 9 Feb 1987 at 15- × 20-cm spacing in 20-m2 plots. Insecticides were applied 20 and 70 d after transplanting (DT).

Except for WBPH, no other pests appeared in appreciable numbers. WBPH population was counted at peak activity and 1 d before and 3 d after the second insecticide application.

At 69 DT, as many as 109 WBPH/ hill were counted in check plots (see table). Carbofuran-treated plots had

**Effect of some insecticides on WBPH population in summer rice. Sambalpur, Orissa, India, 1987.**

| Insecticide[a] | Formulation | Dose (kg ai/ha) | WBPH population/hill[b] 69 DT | 74 DT | Grain yield (t/ha) |
|---|---|---|---|---|---|
| Chlorpyrifos | 10 G | 1.0 | 96.6 | 48.5 | 5.1 |
| Ethoprofos | 10 G | 1.5 | 137.1 | 44.8 | 5.9 |
| Cartap | 4 G | 1.5 | 19.3 | 5.2 | 6.4 |
| Carbofuran | 3 G | 1.0 | 2.5 | 1.9 | 6.8 |
| Chlorpyrifos | 40 EC | 0.5 | 89.1 | 11.6 | 5.3 |
| Decamethrin + buprofezin | 5.9 EC | 0.09 | 29.1 | 7.4 | 5.6 |
| Phosalone | 35 EC | 0.5 | 65.5 | 33.1 | 5.3 |
| No insecticide | – | – | 109.3 | 97.3 | 5.0 |
| LSD (0.05) | | | 48.8 | 21.7 | 0.4 |

[a]Applied at 20 and 70 DT. [b]Mean of 10 hills.

the lowest population; cartap and decamethrin + buprofezin had moderate populations. Ethoprofos granules applied 20 DT did not restrict WBPH multiplication at booting; populations on that plot were higher than in the control.

Insecticides applied 70 DT significantly reduced WBPH populations. Carbofuran (1.0 kg ai/ ha) and cartap (1.5 kg ai/ha) were most effective, followed by decamethrin + buprofezin (0.09 kg ail ha) and chlorpyrifos (0.5 kg ai/ha) spray. □

## Residues of monocrotophos in rice

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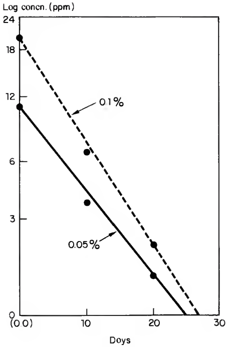
We studied residues of monocrotophos (3-[dimethoxy phosphinyl oxy]- *N* -methyl-cis-crotonamide), a common pesticide, in rice variety Lalat (ORS26-2014). The pesticide was sprayed at the recommended level (0.05%, or 0.25 kg ai/ ha) and double the recommended level (0. 1%, or 0.50 kg ai/ ha). Triplicate plant samples were collected at 0, 10, 20, and 30 d after spraying and at harvest.

The spectrophotometric method was used to estimate residues of monocrotophos, using p-nitrobenzyl pyridine as the chromogenic reagent. Recovery of monocrotophos from fortified samples was 83.2-84.5%.

Mean initial residues of 10.97 ppm (0.05%) and 19.91 ppm (0.01%) were reduced to 3.26 and 5.19 ppm 10 d after pesticide application, to 1.14 and 2.11 ppm 20 d after application, and to nondetectable levels 30 d after application. Dissipation was 89.5% for both application levels 20 d after application.

Rate of degradation with both application levels seemed to follow the first-order reaction (see figure). Fifty percent of the toxicant was reduced at




Linear plot of first-order reaction of monocrotophos in rice. Bhubaneswar, India.

2.4 d at 0.05% application level and at 2.3 d at 0.1%. The safe waiting period ($T_{tol}$) was 17.8 d and 19 d.

Grain and straw samples had nondetectable levels of monocrotophos. □

## Preliminary observations on *Entomophthora delphacis*

*Li Hongke, Institute of Plant Protection, Hunan Academy of Agricultural Sciences, Changshu, China*

The pathogen *E. delphacis* of brown planthopper (BPH) *Nilaparvata lugens* is an important entomogenous fungus widely distributed in irrigated ricefields of South China. It attacks mainly BPH, whitebacked planthopper, and small brown planthopper. It also infects zigzag striped leafhopper and green leafhopper (GLH).

*E. delphacis* usually are most abundant during the overcast and rainy season. in later growth stages of long-duration rice. Infection percentages reach 70-80% when temperatures are 10-20 °C (day-night) with relative humidity more than 90%. In the Changsha region, the numbers of BPH infected by *E. delphacis* ranged from 37% to 64%. In 1985, a year of high humidity, infection reached 69.7%. In 1986, a dry year, infection was only 27.3%.

We used a fungus suspension on artificial media and naturally infected insects for bioassay to determine virulence on BPH and GLH in the laboratory. Results are presented in the table. Mortality of naturally infected insects was higher than that of artificially infected insects. □

**Virulence of *E. delphacis* in the laboratory. Changsha, China.**

| Pathogen source | Insect tested | Insects (no.) | Mortality (%) after infection | | |
|---|---|---|---|---|---|
| | | | 2 d | 4 d | 6d |
| Natural | BPH | 139 | 22.8 | 53.3 | 68.3 |
| | GLH | 92 | 18.0 | 32.4 | 61.1 |
| Artificial [a] | BPH | 120 | 6.3 | 18.4 | 31.2 |
| | GLH | 120 | 2.7 | 11.3 | 24.3 |
| Control (water) | BPH | 110 | 1.8 | 1.8 | 2.7 |
| | GLH | 73 | 2.7 | 2.7 | 2.7 |

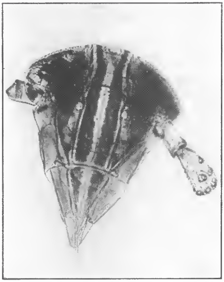
[a] Sabouraud's agar + egg yolk.

## *Toya* spp. planthopper incidence on *Brachiaria mutica*

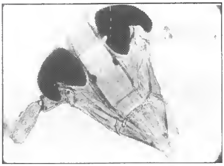
*P. Baskaran, M. Jayanthi, and G. Shankar, Enotmology Department, Faculty of Agriculture, Annamalai University, Annamalainagar 608002, India*

*Brachiaria mutica,* cultivated in about 15 ha at the Annamalai University Sewage Farm, exhibited severe hopperburn symptoms in Feb 1986 and again in Oct. Investigations revealed abundant numbers of a planthopper.

The delphacid resembles brown planthopper (BPH) *Nilaparvata lugens,* except that it is smaller. Both brachypterous and macropterous forms were seen in large numbers Oct-Dec 1986: smaller numbers are seen throughout the year.



**1.** Head of the planthopper, showing the characteristic vertical bands.



**2.** Head of the BPH.

The head of the planthopper shows vertical black bands on the frons (Fig. 1). These appear to be its characteristic feature, and are not seen in BPH (Fig. 2). The ventral side of the abdomen in the 4th- and 5th-instar nymphs shows a pair of distinct black spots laterally on either side near the 5th segment.

Specimens have been identified as *Toya* spp. by CAB International Institute of Entomology, London.

Although ricefields adjacent to the Sewage Farm were not infested with this planthopper, adult females caged after 5 h of starvation on 40-d-old IR50 rice seedlings were found to thrive for the next 56 h.

Usually, the planthopper moves more swiftly than BPH, but becomes less active after a starvation period. Insects regain their natural poise after a few hours on rice plants, indicating possible force-feeding. Actual feeding experiments on rice seedlings showed a mean weight of 7.0 mg honeydew/adult as against 22.7 mg on the regular host.

No survival occurred among 40 freshly hatched nymphs confined on 35-d-old IR50 rice seedlings.

After 56 h on rice plants, the insects had oviposited an average 26 eggs/ insect, in batches of 6-9 eggs. □

## Chemical control of thrips *Stenchaetothrips biformis* in the rice nursery

*V. V. Madhusudhan and M. Gopalan, Agricultural Entomology Department, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore 641003, India*

Spray formulations of phosphamidon, monocrotophos, phosalone. chlorpyrifos, metasystox, endosulfan, dimethoate, and neem oil were evaluated for control of rice thrips in the rice nursery. The field experiment with nine treatments including control was laid out in a randomized block design with three replications.

Pregerminated seeds of IR20 were sown in 0.5-$m^2$ plots. Thrips infestation was noticed 10 d after sowing and pretreatment counts were taken on 15 randomly selected seedlings. Counts were taken at 24, 48, and 72 h, and 1 wk, and 2 wk after treatment.

All chemicals were significantly effective in controlling thrips (see table). Chlorpyrifos, dimethoate, and monocrotophos were best. Although neem oil did not reduce thrips population significantly 24 h after application, it did reduce population at 48 and 72 h after application. □

**Effect of insecticides for thrips control.[a] Coimbatore, India.**

| Treatment | Population[b] (no.) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Pretreatment | 24 h | 48 h | 72 h | 1 wk | 2 wk | Mean |
| Phosalone (0.07%) | 5.9 | 0.2 ab | 0.9 ab | 0.4 a | 1.4 b | 4.5 d | 1.7 b |
| Chlorpyrifos (0.04%) | 5.1 | 1.1 ab | 0.9 b | 0.7 abc | 0.7 a | 1.2 a | 0.9 a |
| Monocrotophos (0.04%) | 6.6 | 0.9 a | 0.3 a | 0.4 a | 1.5 b | 3.1 c | 1.2 a |
| Metasystox (0.04%) | 6.9 | 1.7 b | 0.6 ab | 0.5 ab | 1.8 b | 3.4 c | 1.6 b |
| Dimethoate (0.04%) | 5.2 | 1.2 ab | 0.6 ab | 0.5 a | 0.6 a | 1.9 b | 0.9 a |
| Phosphamidon (0.04%) | 5.4 | 1.7 b | 0.9 b | 0.9 abc | 0.9 abc | 3.6 c | 1.8 b |
| Endosulfan (0.05%) | 5.4 | 2.5 c | 1.6 c | 1.0 c | 1.9 c | 4.8 d | 2.4 c |
| Neem oil (2.0%) | 5.7 | 4.9 d | 1.8 c | 1.4 d | 2.3 c | 4.3 d | 2.9 d |
| Control | 5.7 | 4.8 d | 5.8 d | 6.4 e | 7.6 d | 7.8 e | 6.5 e |
| Period mean | | 2.2 b | 1.5 a | 1.4 a | 2.2 b | 3.8 c | |

[a]Mean of 45 seedlings. [b]In a column, means followed by a common letter are not significantly different by DMRT at the 5% level. In a row, means followed by a common letter are not significantly different by DMRT at the 5% level.

## Alternate ricefield hosts of the Angoumois grain moth

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The Angoumois grain moth *Sitotroga cerealella* is an important pest of rice, wheat, barley, millet, and maize. Field infestation is carried to storage, where is causes severe losses in quality and quantity.

Field infestation on different hosts can identify source of inoculum for rice and other cereals. In places where rice is grown in a particular season, the pest may survive on alternate hosts in other seasons to reinfest the next rice crop.

Information on field infestation also will help determine prophylactic sprays in endemic areas or help in devising an appropriate Angoumois grain moth management system for rice.

We collected 10 panicles/ plot at random from 6 fields of sorghum, pearl millet, and maize 1 wk before harvest Jan-Feb 1986. Ten 100-g samples of rice were collected from 12 plots at harvest and at threshing. Hundreds of panicles of weeds on ricefield bunds were collected from 10 plots. The samples were stored in plastic containers in the laboratory and moth emergence observed after 1 mo.

Field infestation was found in rice, sorghum, maize, pearl millet, and the weed *Echinochloa colona*. The occurrence of *S. cerealella* on pearl millet and *E. colona* are new records of field infestation.

The number of moths that emerged was highest in pearl millet (26-32/panicle), followed by sorghum (18-20) and maize (6-12). Moth emergence in rice was 3-8/100 g. The lowest number of moths (4/100 panicles) emerged in *E. colona*, and they were very small (1.0-1.5 mm long). □

## Susceptibility of field strains of smaller brown planthopper (SBPH) in Taiwan to six insecticides

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Before 1984, only carbofuran was recommended to control SBPH in Taiwan; SBPH had been considered a secondary pest of rice. However, during the last few years, SBPH incidence has resulted in serious damage to rice in central and southern parts of the island. Carbofuran, buprofezin, and flucythrinate have been commonly used for control.

We studied susceptibility of four field strains of SBPH to six insecticides.

An acetone solution of 4-5 concentrations of each insecticide was sprayed onto 4th-instar nymphs. Each concentration had 3 replications; 45 insects were tested. When a synergist was used, the nymphs were sprayed with an acetone solution of the synergist 1 h before insecticide treatment. Mortality was recorded 24 h after treatment.

Flucythrinate and fenvalerate were the most effective insecticides (see table). (Note that both pyrethroids have an a-isopropylphenyl group in their acid moiety.) Cypermethrin exhibited intermediate effectiveness against SBPH, and permethrin was considerably less potent. Carbofuran appeared less toxic than all pyrethroids except permethrin. Malathion was practically useless.

Limited synergism data showed that the toxicity of permethrin could be enhanced about 50 times by tributyl phosphorotrithioate, an inhibitor of esterases. Synergism of permethrin by piperonyl butoxide, which inhibits microsomal oxidases, was limited. Synergism of cypermethrin by either synergist was not as significant as that of permethrin.

In view of these results, we suggest that SBPH in Taiwan has become resistant to malathion and permethrin but remains susceptible to fenvalerate, flucythrinate, and cypermethrin.

Resistance to permethrin, and very possibly to malathion, is closely related to hydrolytic degradation by esterases. This resistance mechanism resembles that we found earlier in the brown planthopper (BPH). In BPH, high esterase activity associated with organophosphorus and carbamate resistance may have conferred a major part of the resistance to permethrin and other primary alcohol ester pyrethroids. □

**Susceptibility of 4 field strains of SBPH in Taiwan to 6 insecticides.**

| Insecticide[a] | Field strain $LC_{50}$[b] (µg/ml) | | | |
|---|---|---|---|---|
| | Ping-tung | Tai-chung | Chia-yi | I-lang |
| Permethrin | 1,272 | 2,531 | 693 | 2,093 |
| + TBPT | 25.3 (50) | 49.1 (52) | – | – |
| + PB | 510 ( 2.5) | 212 (12) | – | – |
| Cypermethrin | 25.9 | 41.7 | 43.0 | 13.1 |
| + TBPT | 5.6 ( 3.6) | 14.1 (3.0) | – | – |
| + PB | 4.8 ( 5.4) | – | – | – |
| Fenvalerate | – | 7.1 | 6.0 | 10.2 |
| Flucythrinate | 3.9 | 55 | 3.9 | 15.1 |
| Carbofuran | – | 96.9 | 52.4 | 61.6 |
| Malathion | 3,458 | 5343 | 10,129 | 4,120 |

[a]TBPT = tributyl phosphorotrithioate, at 50 µg/ml. PB = piperonyl butoxide, at 25 µg/ml. [b]Figures in parentheses represent $LC_{50}$ of unsynergized insecticide/$LC_{50}$ of synergized insecticide.

# Managing other pests

## Ufra - a first report in Orissa, India

*S. Ray and S. N. Das, Nematology Department, Orissa University of Agriculture and Technology, Bhubaneswar, India; and H. D. Catling, IRRI*

Ufra caused by *Ditylenchus angustus* has been recorded for the first time in Orissa. It was found on tall indica local variety Rangi in Dapa village, Balasore District, usually a deepwater rice area. However, in 1987 the habitat was atypical, with only a few centimeters standing water in the field because of the unusual drought. Affected plants are stunted with withered boot leaf and sheath. Panicles are very much reduced

Ufra-infected plants in Orissa, India, 1987.

in size, often partially emerged, deformed, and chaffy (see figure).

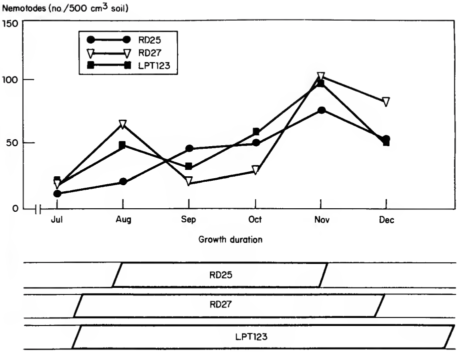
Large numbers of males and juveniles but only a few females of the nematode were recovered from the axils of affected boot leaves.

Symptoms of ufra had been found before in Cuttack and Balasore, but the nematode could not be recovered. The current identification confirms presence of the nematode in a new locality and in a new habitat. □

## Population dynamics of rice root nematode *Hirschmanniella oryzae* in rice of different durations

*L. Arayarungsarit and S. Junbuthong, Parhum Thani Rice Research Center, Thanyaburi Pathum Thani 12110, Thailand*

We measured the population density of *H. oryzae* from 500-cm$^3$ soil samples taken monthly in Jul-Dec 1987 from field plots where RD25, RD27, and LPT123 were grown as short-, medium-, and long-duration varieties. RD27 and LPT123 were seeded in Jul, RD25 in Aug. RD25 was harvested in Nov, RD27 in Dec, and LPT123 in Jan.




Density of rice root nematode *H. oryzae* in rice varieties of different durations at Pathum Thani Rice Research Center, Thailand, 1987 wet season.

Nematode population in RD25 had only one peak—in Nov (see figure). Both RD27 and LPT123 had two peaks—Augand Nov. Highest population density in all varieties occurred in Nov. □

## Host range and feeding preference of golden apple snail

*R. P. Basilio and J. A. Litsinger. Entomology Department. IRRI*

Golden apple snail *Pomacea canaliculata* has become an important pest of rice in the Philippines. During the prerice planting period, golden apple snails are usually found in irrigation canals and drainage ditches, where they may be feeding on weeds.

We tested eight common species of lowland weeds and rice to determine the host range and feeding preference of golden apple snail.

**Table 1. Golden apple snail host preference. IRRI, 1987.**

| Plant species | Plants (5%) consumed by the snails[a] at indicated time (h after infestation) | | | |
|---|---|---|---|---|
| | 4 h | 24 h | 48 h | 72 h |
| *Monochoria vaginalis* | 50 a | 100 a | 100 a | 100 a |
| *Echinochloa glabrescens* | 40 a | 100 a | 100 a | 100 a |
| *Cyperus difformis* | 35 a | 90 a | 100 a | 100 a |
| *Oryza sativa* | 0 b | 100 a | 100 a | 100 a |
| *Fimbristylis miliacea* | 0 b | 100 a | 100 a | 100 a |
| *Paspalum distichum* | 20 ab | 55 b | 85 ab | 90 a |
| *Ipomoea aquatica* | 0 b | 20 c | 75 b | 85 a |
| *Sphenoclea zeylanica* | 0 b | 48 b | 52 c | 52 b |
| *Pistia stratiotes* | 0 b | 30 bc | 45 c | 48 b |

[a]Av of 10 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 2. Young and old plants as preferred hosts of golden apple snail. IRRI, 1987.

| Plant species | Plants consumed (%) 48 h after infestation[a] | |
|---|---|---|
| | Young | Old |
| *Monochoria vaginalis* | 93 a | 54 b |
| *Paspalum distichum* | 18 a | 15 b |
| *Echinochloa glabrescens* | 77 a | 6 b |
| *Cyperus difformis* | 68 a | 58 b |
| *Fimbristylis miliacea* | 59 a | 27 b |
| *Sphenoclea zeylanica* | 50 a | 32 b |
| *Pistia stratiotes* | 28 a | 24 b |
| *Ipomoea aquatica* | 6 a | 1 b |

[a]Av of 5 replications. In a row, means followed by a common letter are not significantly different at the 57% level by DMRT.

Each female (4-5 cm height) was given 0.5 g of each test weed species (20- to 30-d-old) on 29-cm-diam GI sheet trays covered with mylar film cages. The setup had 10 replications. The amount consumed by the snails is shown in Table 1.

In a separate experiment, 7 g each of 2 weed stages (20- to 30-d-old and more than 40-d-old) were placed on each GI sheet tray and infested with 2 golden apple snails/ tray. The experiment had 5 replications. The amounts consumed by the snails were compared (Table 2).

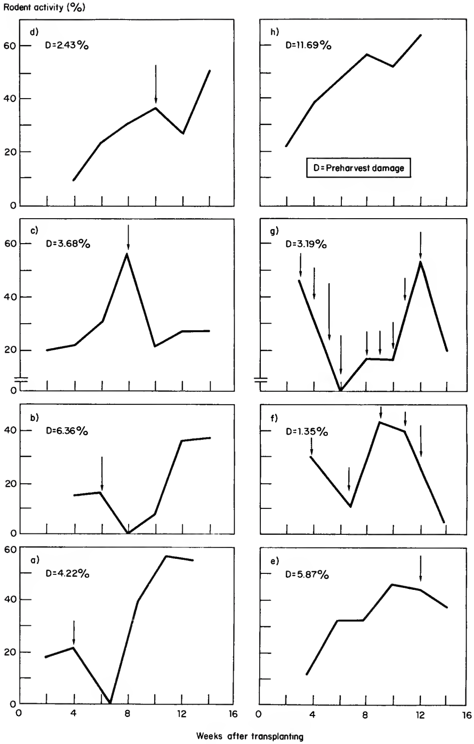
Golden apple snails appear to have a wide host range and to feed on almost all lowland weeds. They prefer the soft, young parts of the plant. □

## Single-dose anticoagulants for rodent control in irrigated ricefields

*G. Chopra, Zoology Department, Kurukshetra University, Kurukshetra 132119, India*

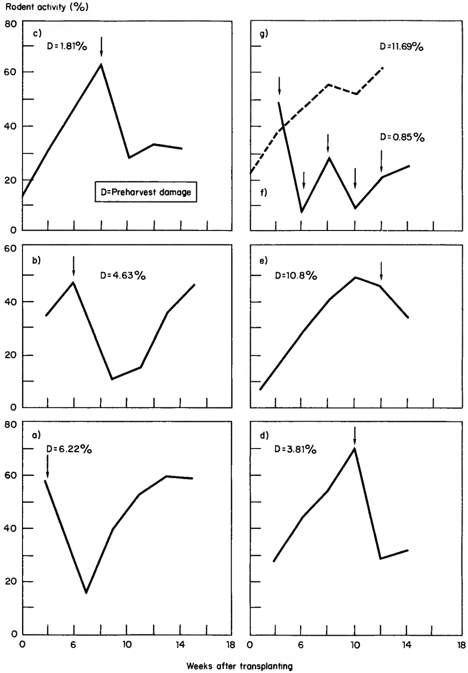
We tested two singledose anticoagulants—bromadiolone and brodifacoum—to establish the . appropriate time for rodent poison baiting.

Of 15 rodent species of economic importance in India, *Bandicota bengalensis, Rattus meltada,* and field mice *Mus* spp. cause huge rice crop losses in northern India. At early stages of rice growth, the rodents are confined to bunds and adjacent permanent pathways. They migrate inside the fields at crop maturity. As much as 12% tiller damage by rodents was assessed in reference fields.




1. Exposure of 0.005% bromadiolone bai at different weeks after transplanting. Arrows indicate time of poison baiting. Treatment at a) 4 WT, b) 6 WT, c) 8 WT, d) 10 WT, e) 12 WT, f) multiple baiting, g) continuous baiting in bamboo bait stations, h) activity in reference fields.

Treatment for rodents on bunds and adjacent pathways at 8-10 wk after




2. Exposure of 0.005% ready-to-use brodifacoum wax blocks at different weeks after transplanting. Arrows indicate time of poison baiting. Treatment at a) 4 WT, b) 6 WT, c) 8 WT, d) 10 WT, e) 12 WT, f) multiple baiting, g) activity in reference fields.

transplanting (WT) with 0.005% bromadiolone bait or 0.005% ready-to-use brodifacoum wax blocks resulted in maximum kill and 70-80% reduction in preharvest tiller cut damage (Fig. 1, 2). Poison baiting at 4 WT or 6 WT with either anticoagulant also was effective in killing rodents.

A large-scale immigration of rodents from surrounding areas near crop maturity resulted in high preharvest tiller damage. Treatment at 12 WT was not effective. Intake of poison bait declined significantly because of the availability of maturing rice grains.

Multiple poison baiting of rodents with 0.005% bromadiolone or 0.005% brodifacoum baits at 4, 6, 8, 10, and 12 WT was most effective in killing existing and immigrating rodent populations.

Bamboo bait stations were used for poison baiting during rainy days. Early consumption of 0.005% bromadiolone bait from these bamboo bait stations was substantial, resulting in high decline in rodent populations, but consumption declined considerably 10 WT. ☐

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## Grain loss due to rat damage

*T. R. Kapoor, Entomology Department, Haryana Agricultural University, Hisar; and K. S. Kushwaha, Rice Research Station, Kaul (Kurukshetra), India*

Of the known pests, the field rat *Bandicota bengalensis* causes substantial losses to the rice crop from sowing to harvest in Haryana.

We surveyed 171 fields in 11 villages of 4 blocks of Kurukshetra district, where mainly Jaya, PR106, and IR8 varieties are grown, from August to harvest in 1984. Maximum damage occurred at tillering and heading stages; tillers were cut 10-15 cm from the ground. The number of rat burrows varied from 2 to 13/field (0.4 ha), and they were confined to field boundaries. Cut tillers were found 5-15 m away from the burrows.

From field samples, we assessed yield losses caused by rats by taking the yield corresponding to the number of cut tillers/m$^2$ and the yield of healthy tillers/ m$^2$. Cut tillers/m$^2$ varied from 5.2 to 47.5, grain yield losses ranged from 33.8 to 308.8 g/m$^2$. That can be estimated as 0.4 to 3.1 t/ ha for Jaya, 0.6 to 1.9 t/ha for PR106, and 0.4 t/ ha for IR8 (see table). Rats showed no varietal preference. The yield loss differences among varieties may be due to variations in size of the rat population in different villages. ☐

**Grain yield losses due to rats at Kurukshetra, India, 1984.**

| Block | Village | Fields observed (no./village) | Variety | Av cut tillers/m$^2$ | Grain loss (g/m$^2$) | Yield loss (t/ha) |
|---|---|---|---|---|---|---|
| Thanesar | Shadipur | 25 | Jaya | 47.5 | 308.8 | 3.1 |
| | Kanipla | 15 | Jaya | 34.5 | 224.1 | 2.2 |
| | Kanpur | 18 | PR106 | 28.6 | 185.7 | 1.9 |
| | Hinga Kheri | 11 | PR106 | 13.2 | 87.8 | 0.9 |
| Shahabad | Kalsani | 16 | PR106 | 8.7 | 56.6 | 0.6 |
| | Nagla | 13 | Jaya | 18.0 | 117.0 | 1.2 |
| Pehowa | Sandhali | 10 | IR8 | 5.2 | 33.8 | 0.4 |
| | Saina Saida | 15 | PR106 | 12.5 | 81.2 | 0.8 |
| | Gumthala | 22 | Jaya | 30.2 | 196.0 | 2.0 |
| Cheeka | Sonthi | 14 | Jaya | 6.4 | 41.3 | 0.4 |
| | Kakkahri | 12 | Jaya | 8.0 | 52.0 | 0.5 |

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# Water management

## Supplementary irrigation of upland crops following rice

*D. Chandra, Central Rice Research Institute (CRRI), Cuttack 753006; N. L. Meena, Krishi Anusandhan Bhavan, New Delhi 110012; and K. C. Das, CRRI, India*

We studied the supplementary irrigation requirement of rabi pulses and oil seeds grown in residual moisture following rice on slightly sloping land.

Crops were sown on 16 Dec 1985. Mungbean was harvested on 18 Mar, urdbean on 25 Mar, and peanut on 1 Apr 1986. A total 77.4 mm of rainfall was received during crop growth. The groundwater table remained at about 80 cm depth (78-83 cm) during the cropping season.

Peanut performed best under residual moisture without irrigation, yielding about 0.7 t/ ha (Table 1). One irrigation at flowering almost doubled peanut yield to 1.4 t/ha. Further irrigation did not result in any significant increase in yield.

Total supplementary water used was 77.4, 127.4. 177.4, and 227.4 mm in the treatments of no irrigation, 1 irrigation, 2 irrigations, and 3 irrigations, respectively (Table 2). □

**Table 1. Grain yield of crops following rice under different moisture regimes. New Delhi, India.**

| Treatment | Yield (t/ha) | | | |
|---|---|---|---|---|
| | Peanut | Mungbean | Urdbean | Mean |
| Residual moisture | 0.71 | 0.11 | 0.15 | 0.32 |
| Irrigation at flowering | 1.36 | 0.10 | 0.18 | 0.54 |
| Irrigation at flowering + pod initiation | 1.28 | 0.12 | 0.19 | 0.53 |
| Irrigation at flowering + pod initiation + pod elongation | 1.36 | 0.18 | 0.17 | 0.54 |
| Mean | 1.18 | 0.09 | 0.17 | – |
| LSD (0.05) for moisture regimes | | | | 0.08 |
| for crops | | | | 0.11 |
| for 2 crops under Same moisture regime | | | | 0.22 |
| for 2 moisture regimes for same crop or different crops | | | | 0.18 |

**Table 2. Irrigation requirement under different moisture regimes. New Delhi, India.**

| Treatment | Irrigations (no.) | Water applied (mm) | | Total water needed (mm) including rainfall |
|---|---|---|---|---|
| | | Irrigation | Rainfall | |
| Residual moisture | 0 | 0 | 77.4 | 77.4 |
| Irrigation at flowering | 1 | 50 | 77.4 | 127.4 |
| Irrigation at flowering + pod initiation | 2 | 100 | 77.4 | 177.4 |
| Irrigation at flowering,+ pod initiation + pod elongation | 3 | 150 | 77.4 | 227.4 |

## Effect of water regime on yield and water use of rice

*R. Singh and U. V. Singh, Soil Science Department, G. B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttar Pradesh, India*

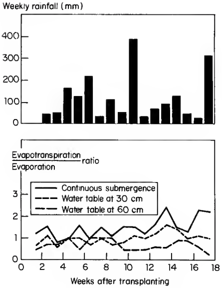
We studied the effect of three water regimes on yield and water used for evapotranspiration (ET) during 1985 kharif (Jun-Oct) at Pantnagar (29° N, 79° 3' E). Treatments were continuous submergence of 5±1 cm and static water tables at 30 cm and 60 cm depths below soil surface.

The experiment was carried out in 3 replications in field-installed RCC tank lysimeters 1.8 × 1.5 m area and 1.5 m depth filled with Beni silty clay loam series (Mollisol) soil of Pantnagar. Soil had 9% sand, 61% silt, and 30% clay; pH 6.3; cation exchange capacity 20.0 meq/100 g; bulk density 1.33 g/cm$^3$; 3.4% organic matter; retained 34.6%, moisture at 1/3 bar and 11% at 15-bar tension; and hydraulic conductivity of 0.82 cm/h. ET was calculated from daily change in water table (considering soil

**Rice yield and evapotranspiration (ET) under different irrigation treatments. Uttar Pradesh, India.**

| Treatment | Yield (kg/2.7 $m^2$) | | ET (mm) during different growth phases[a] | | | | Water use efficiency (kg/ha-mm) |
|---|---|---|---|---|---|---|---|
| | Grain | Straw | Vegetative | Reproductive | Ripening | Total | |
| Continuous submergence | 1.91 | 2.33 | 368 (54) | 222 (33) | 92 (13) | 682 | 10.4 |
| Water table at 30 cm | 1.54 | 1.90 | 268 (56) | 168 (35) | 44 (9) | 480 | 11.9 |
| Water table at 60 cm | 1.36 | 1.53 | 248 (70) | 90 (25) | 19 (5) | 357 | 14.1 |
| LSD (0.05) | 0.29 | 0.45 | | | | | |

[a]Vegetative = 10 wk, reproductive = 6 wk, and ripening = 2 wk. Figures in parentheses are percent of total.




Evapotranspiration behavior of rice under different water regimes. Uttar Pradesh, India.

porosity) or change in submergence level and replenished accordingly. Rainfall contribution was accounted for. The total 1,990 mm rainfall received was well distributed over the growing season.

Continuous submergence gave significantly higher grain yield than water tables maintained at 30 cm and 60 cm depths (see table). But water use efficiency was highest with 60 cm water table and least with continuous submergence (see figure).

The rate of water used as ET was highest in continuous submergence and depended a great deal on rainfall in any particular week. Water use was lowest with 60 cm water table and intermediate with 30 cm water table. The differences in ET became more pronounced later in the season.

The total water use as ET with continuous submergence was nearly double that with 60 cm water table. In all treatments, a major portion of total water was used during the vegetative phase; only one-fourth to one-third was used during the reproductive phase. With the 60 cm water table, more than two-thirds total ET was during the vegetative phase. □

# Farming systems

## Intercropping of pulses with rainfed rice at South Coastal Orissa, India

*P. N. Sahu, A. K. Padhi, and N. Dash, Orissa University of Agriculture and Technology, Agriculture Research Station, Berhampur, India*

We studied a feasible rice-based intercropping system to assure grain yield in at least one crop in case of erratic monsoon or other natural calamity. Under favorable climatic conditions, the additional income from an intercrop would augment earnings of small and marginal farmers.

Single crop rice (Parijat) was sown at 20- × 10-cm spacing. Green gram (K851), black gram (T9), peanut (AK12-24), red gram (Upas 120), and cowpea (C152) were sown as intercrops in rice: intercrop proportions of 1:1 (20 cm), 1:2 (20,60 cm), 2:1 (20,60 cm), and 2:2 (20,60 cm), in a randomized block design with 4 replications.

Soil was sandy loam with pH 5.60, 0.21% organic C, 18 kg available P/ha, and 227 kg exchangeable K/ha. Rice received 40-20-20 kg NPK/ha in 2 splits; pulses received 20-40-0 kg NPK/ ha as basal.

**Grain yield of rice and intercrops. Berhampur, India.**

| Intercropping system | Yield (t/ha) | | | Return ($/ha) | | |
|---|---|---|---|---|---|---|
| | Main crop (rice) | Intercrop | Total | Main crop | Intercrop | Total |
| Rice + green gram | 1.2 | 0.26 | 1.43 | 232 | 128 | 360 |
| Rice + black gram | 1.3 | 0.39 | 1.78 | 254 | 192 | 446 |
| Rice + peanut | 1.1 | 0.67 | 1.72 | 299 | 358 | 657 |
| Rice + red gram | 0.9 | 0.36 | 1.26 | 179 | 223 | 402 |
| Rice + cowpea | 1.1 | 0.40 | 1.51 | 221 | 214 | 435 |
| Monocrop rice | 2.2 | ** | 2.23 | 444 | ** | 444 |
| Intercrop mixture | | | | | | |
| 1:1 | 1.7 | 0.50 | 2.22 | ** | ** | ** |
| 1:2 | 1.0 | 0.59 | 1.63 | ** | ** | ** |
| 2:1 | 0.9 | 0.32 | 1.25 | ** | ** | ** |
| 2:2 | 0.7 | 0.41 | 1.13 | ** | ** | ** |
| LSD (0.05) | ** | ** | ns | ** | ** | ** |

Single crop rice produced 2.23 t/ha (see table). The rice yield was affected to different degrees by the intercrop. Highest rice yield was in rice + black gram at all proportions.

In the intercrops, peanut yielded the most (0.67 t/ha). The 1:2 intercrop resulted in higher intercrop yields (0.59 t/ha). □

## Rice-based cropping system in Lower Bhavani Project area in Tamil Nadu, India

*K. V. Selvaraj, R. Kulandaivelu, B. Rajkannan, and P. Muthuvel, Tamil Nadu Agricultural University, Agricultural Research Station, Bhavanisagar 638451 India*

In the Lower Bhavani Project command area, water is released in alternate years to a rice crop and a peanut crop. When there is no water, farmers who have a groundwater resource go in for sugarcane, turmeric, cotton, and other crops.

We studied four cropping sequences in a red sandy loam soil during 1984-85. A rice-based sequence with sesamum, pearl millet, turmeric, and cotton gave the highest net profit ($2,998) with a cost-to-benefit ratio of 1.15 (see table).

This sequence could increase productivity in the region by 174%. It would reduce water use for the 2-yr period from 482 to 411 cm. □

**Two-year rice-based cropping system yield, water consumption, and net return. Bhavanisagar, India, 1984-85.**

| Crop sequence and yield (t/ha) | Net return (US$) | Cost:benefit ratio | Water consumption (cm) |
|---|---|---|---|
| 1. Rice (3.6)<br>peanut (1.52)<br>sesamum (0.07)<br>Rice (3.4)<br>peanut (1.59)<br>sesamum (0.58) | 1095 | 0.54 | 482 |
| 2. Rice (3.6)<br>sugarcane (105.9)<br>sesamum (0.58)<br>peanut (1.52) | 1192 | 0.60 | 409 |
| 3. Rice (3.4)<br>sesamum (0.71)<br>pearl millet (2.78)<br>turmeric (16.76)<br>peanut (1.5 6) | 2393 | 1.07 | 404 |
| 4. Rice (3.6)<br>sesamum (0.72)<br>pearl millet (2.86)<br>turmeric (15.76)<br>cotton (2.15) | 2998 | 1.15 | 411 |

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## Performance of rice after potato, mustard, and fallow in Bangladesh

*P. K. Biswas, M. Akhteruzzaman, and A. Quasem, Regional Agricultural Research Station, Hathazari, Chittagong, Bangladesh*

We conducted a 2-yr field trial Nov-Jun 1985-86 and 1986-87 to study the performance of rice after potato, mustard, and fallow with 0, 2, and 4 plowings per farmers' practice. Nine treatments were tested in a split-plot design with three replications.

Soil belonged to Sylok series, silty clay loam texture. Potato and mustard were sown in Nov for both years. Potato received 102-100-100 and mustard 80-60-40 kg NPK/ha. After harvest, the land was tilled using a bullock. Rice, 45-d-old BR3 (Biplab) seedlings, was transplanted at 25- × 15-cm spacing with 80-60-40 kg NPK/ha. NPK was applied as urea, triple superphosphate, and muriate of potash.

Highest yield of rice was after potato (Table 1). Rice after mustard and in fallow gave identical yields.

Rice yield increased with number of plowings (Table 2). □

**Table 1. Yield and yield attributes of rice following potato, mustard, and fallow.[a] Bangladesh, 1985-87.**

| Previous crop | Yield (t/ha) | | Effective tillers (no./$m^2$) | | Field grains/ panicle | | 1000 grain wt (g) | |
|---|---|---|---|---|---|---|---|---|
| | 1985-86 | 1986-87 | 1985-86 | 1986-87 | 1985-86 | 1986-87 | 1985-86 | 1986-87 |
| Potato | 4.7 a | 4.4 a | 302 | 293 | 74 | 62 a | 27.81 | 27.09 |
| Mustard | 3.3 b | 3.4 b | 275 | 265 | 66 | 52 b | 27.21 | 26.93 |
| Fallow | 3.3 b | 3.4 b | 257 | 258 | 67 | 58 ab | 26.17 | 26.98 |

[a]Mean of 3 replications. In a column, means followed by a common letter are not significantly different at the 5% level by LSD.

**Table 2. Yield and yield attributes of rice with different numbers of plowings.[a] Bangladesh, 1985-87.**

| Plowings (no.) | Yield (t/ha) | | Effective tillers (no./$m^2$) | | Field grains/ panicle | | 1000 grain wt (g) | |
|---|---|---|---|---|---|---|---|---|
| | 1985-86 | 1986-87 | 1985-86 | 1986-87 | 1985-86 | 1986-87 | 1985-86 | 1986-87 |
| Zero | 3.2 b | 3.2 b | 272 | 257 | 67 | 50 b | 26.41 | 26.89 |
| Two | 3.8 ab | 3.7 ab | 280 | 276 | 71 | 60 a | 26.82 | 26.90 |
| Four | 4.4 a | 4.3 a | 284 | 283 | 70 | 63 a | 27.82 | 27.21 |

[a]Mean of 3 replications. In a column, means followed by a common letter are not significantly different at the 5% level by LSD.

## Second crop rice in Rajasthan

*R. S. Tripathi and R. Pandya, Agriculture Research Station, Banswara, India*

Nearly 2,000 ha of ricefields in zone IVb of Rajasthan remain waterlogged during the dry season. Because of the tank bed nature, it is not possible to raise wheat or other crops. The zone is characterized by mild, short winters with comparatively high humidity.

We explored raising a rice crop or a ratoon crop during off-season.

Seeds of 10 rice varieties with different growth durations (110-150 d) were sown at 20-d intervals from the first week of Dec 1985 to the second week of Jan 1986. Seedlings were transplanted at the 4-5 leaf stage at 15- × 15-cm spacing under high fertility. The experiment was laid out in a randomized block design with three replications.

Seedling growth in the dry season was slower than in the wet season. It took 2 to 2-1/2 mo to attain the 4-5 leaf stage in all varieties. In the first sowing, plant height ranged from 60 to 85 cm, with 13-37 panicle-bearing tillers. Panicle length ranged from 17.2 to 24 cm. In the second sowing, plant height increased significantly, ranging from 69 to 95.1 cm with 27-47 panicle-bearing tillers. Panicle length also increased significantly. In the last sowing, all the three ancillary characters were drastically reduced.

Short-duration varieties matured 56-78 d after transplanting; medium-duration varieties took an average 90 d to mature (Table 1). Yields were relatively high when seeds were sown in the third week of Dec (more productive tillers and better panicle length). Pusa 2-21, IET7566, and BK79 yielded significantly better than the other varieties.

The ratooning ability of the 10 varieties sown on 25 Dec 1985 was assessed. The main crop was harvested the first week of May 1986. Plants were cut 8 cm from ground level and allowed to ratoon. Fertilizer at 40 kg N and 40 kg P/ha was applied basally just after the main crop harvest; 40 kg N/ha was applied 1 mo after main crop harvest.

Highest grain yield (4 t/ha) was from BK 190, followed by Chambal (3.2 t/ha) and BK398 (2.5 t/ha) (Table 2). All the medium-duration varieties had better ratooning ability; short-duration varieties had poor ability. □

**Table 1. Average yield of rice varieties in off-season. Banswara, India, 1985-86.**

| Variety | Sowing 1 | | Sowing 2 | | Sowing 3 | | Av yield (t/ha) |
|---|---|---|---|---|---|---|---|
| | Days to maturity | Yield (t/ha) | Days to maturity | Yield (t/ha) | Days to maturity | Yield (t/ha) | |
| BK190 | 88 | 2.0 | 92 | 2.0 | 122 | 0.6 | 1.5 |
| BK398 | 81 | 1.7 | 85 | 1.6 | 114 | 0.4 | 1.3 |
| Chambal | 80 | 0.4 | 87 | 2.4 | 112 | 0.7 | 1.2 |
| Ratna | 70 | 0.4 | 78 | 1.9 | 109 | 0.4 | 0.7 |
| BK79 | 73 | 3.0 | 76 | 2.4 | 108 | 1.5 | 2.3 |
| IET7566 | 63 | 1.0 | 65 | 4.0 | 95 | 1.5 | 2.2 |
| Pusa 2-21 | 62 | 3.2 | 69 | 5.2 | 102 | 1.2 | 3.2 |
| BK664 | 64 | 1.5 | 74 | 2.5 | 106 | 1.9 | 2.0 |
| BK665 | 77 | 1.5 | 73 | 0.4 | 105 | 0.9 | 0.9 |
| Av | | 1.5 | | 2.3 | | 0.9 | |
| LSD (0.05) | | 0.9 | | 1.3 | | 0.5 | |
| CV | | 15.4 | | 7.3 | | 9.7 | |

**Table 2. Performance of ratoon crops of rice varieties. Banswara, India, 1985-86.**

| Variety | Ratoon crop | | | | | | Main crop | | |
|---|---|---|---|---|---|---|---|---|---|
| | Days to flowering | Days to maturity | Plant ht (cm) | Panicle-bearing tillers (no.) | Panicle length (cm) | Av yield (t/ha) | Days to flowering | Days to maturity | Av yield (t/ha) |
| BK190 | 57 | 75 | 81.1 | 14 | 20.8 | 4.0 | 112 | 145 | 7.0 |
| BK398 | 49 | 70 | 75.1 | 11 | 21.5 | 2.5 | 110 | 140 | 5.8 |
| BK79 | 50 | 68 | 56.9 | 22 | 19.1 | 2.1 | 102 | 140 | 6.0 |
| BK664 | 49 | 66 | 55.6 | 14 | 17.1 | 1.7 | 90 | 123 | 5.5 |
| BK665 | 49 | 67 | 58.7 | 13 | 18.4 | 2.3 | 93 | 125 | 5.5 |
| IET7564 | 46 | 62 | 69.5 | 19 | 18.6 | 1.2 | 88 | 110 | 3.5 |
| IET7566 | 50 | 65 | 71.8 | 15 | 21.3 | 1.0 | 80 | 109 | 4.0 |
| Pusa 2-21 | 50 | 66 | 51.6 | 15 | 17.2 | 1.5 | 78 | 107 | 4.5 |
| Ratna | 59 | 68 | 56.4 | 20 | 19.5 | 1.6 | 78 | 108 | 4.2 |
| Chambal | 50 | 71 | 56.3 | 19 | 17.9 | 3.2 | 85 | 105 | 3.0 |

LSD (0.05) = 0.4 t/ha
CV = 9.8%

## Fish production from rainfed ricefields in northeast Thailand

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We interviewed 20 farmers participating in a CARE rice - fish culture project in Yasothorn Province weekly during the 1986 rainy season to compare stocked fingerling and wild fish production.

No trenches were dug; catch ponds doubled as fish refuges. Farmers grew photoperiod-sensitive, long-stalked rice varieties such as Dok Mali 105 (ordinary rice) and San Pa Thong (glutinous). Transplanting was completed in late Jun. Fertilizer and manure application varied widely (av 100 kg N/ha). Pesticide (methyl parathion) was sometimes used for crab control before transplanting, but did not cause problems. Harvest was around 20 Nov, averaging 1.5-2 t rice/ha.

Fingerlings (34 cm; US$1/100 fish) of *C. carpio, O. niloticus,* and *P. gonionotus* were stocked 2 Jul at a 2:1:1 ratio. Recommended stocking rate was

3,125 fingerlings/ha, but it varied in practice (see table). Rice bran and broken rice were the supplementary feed (av 167 kg/ha). Catch ponds were pumped dry in Dec-Jan.

Total fish production in 20 fields (5.4 ha) was 1.5 t (see table). Stocked species contributed only 42.8 kg (15%), with mortality calculated at 80%. Predator fish *Ch. striata* and *Cl. batrachus* resp. *Cl. macrocephalus* made up 78% of total yield. These species can travel over land and successfully immigrate into the ricefields. Stocking density did not correlate with stocked fish production. Water level in the ricefield and wild fish yield were significantly correlated ($r$ = 20: p < 0.01).

Rice - fish culture did not contribute much to household nutritional needs, but it did contribute to cash income and social obligations (parties). In Dec, fish sold at about US$l/kg (farm gate), rice at about US$100/t. Cash value of fish yield on the average exceeded the value of rice yield. Stocked fish production minus fingerling costs averaged US$14/ha, only 5.8% of the market value of all wild fish caught. □

**Means and coefficients of variation for fish production from rice-fish fields, stocking density, and rice field size for 20 farmers. Yasothorn, Thailand, 1986 rainy season.**

| | Stocking density (fish/ha) | Fish production (kg/ha) | | Fish production (kg/ha) | | Total fish yield (kg/ha) |
|---|---|---|---|---|---|---|
| | | Stocked fish | Wild fish | Before rice harvest | After rice harvest | |
| Mean | 2814 | 42.8 | 241.3 | 12.6 | 272.5 | 284.8 |
| CV (%) | 58 | 103 | 105 | 147 | 96 | 92 |

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